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SUPER-FLICKERS - AN ON-LINE DATA ACQUISITION SYSTEM FOR THE PDP-8

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ABSTRACT

SUPER-FLICKERS is a system of PDP-8 programs for accumulating and processing 4 parameter data from pulse height and time-of-flight analyzers. It writes all incoming data on magnetic tape for later analysis by a larger computer and provides oscilloscope displays of various 2-dimensional "flicker boxes" on an event by event basis. It also accumulates and plots certain one dimensional combination spectra which are of interest. Program options are controlled by key switches and plot scaling options are controlled by teletype keys.

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I. BRIEF DESCRIPTION OF THE DATA BREAK CONTROL

Data from the pulse-height analyzers enter the interface through the data break control which multiplexes 48 bits into four successive computer words. The "ALERT PULSE" signals the computer when 48 bits are waiting to be inputted. Words are stacked in a buffer region of core whose origin and length are contolled by hardware switches. The buffer region can be either 256_{10} (400_8) or 512_{10} (1000_8) words long. If the length switches are set for a 256-word buffer then the origin switches can be set for any of the locations 0000, 0400, 1000, ..., 7400. For a 512-word buffer the possible origins are 0000, 1000, 2000, ..., 7000. The programs described in this report are written for a 256-word buffer beginning in core location 1000. Switches are also available for controlling the number of words per event and these can be set for any of the numbers 1, 2, 3, or 4. These programs are designed for 4 words per event. The 4 words are referred to in the programs and in this report as words T, B, C, and D though occasionally word T may also be referred to as word G or occasionally as word A. As the 4 words for each new event come into the buffer, an address counter is counted up by 4 so that the next event will occupy the next 4 words in the buffer. This address counter works in a circular fashion so that it starts again at the beginning of the buffer when the end of it is reached. To prevent the data buffer from filling up and new events being written over old events which have not yet been processed the data break contains an up-down counter which counts up the new words coming in and can be counted down by the program as old words are taken out of the buffer and processed. If the data rate becomes fast enough that the data buffer fills up faster than the program can empty it out then each time the buffer is completely filled with unprocessed data the up-down counter overflows and this condition stops new data from coming in until some of the old data has been removed and the up-down counter counted down by the program.

The following machine instructions are used for program control of the data break:

BADCLR Break control ADdress counter CLeaR -- sets the address counter to the address of the first word in the buffer region so that the buffer will start at the position given by the hardware switches.

BABLE Break enABLE in Break control -- enables the data break and allows data to start coming in.

BDISAB Break DISABle in Break control -- disables the data break and stops the data from coming in.

UDCLR Up-Down CLear -- clears the up-down counter and issues an accepted pulse to the interface.

UDSOFL Up-Down counter Skip on OverFLow -- causes the computer to skip the next instruction if the up-down counter is in the overflowed condition.

UDSUB1 Up-Down counter, SUB 1 -- subtracts 1 from the up-down counter.

UDSUB2 Up-Down counter, SUB 2 -- subtracts 2 from the up-down counter.

UDSUB3 Up-Down counter, SUB-3 -- subtracts 3 from the up-down counter.

All the circuits except for the address counter are reset by the POWER CLEAR which accompanies the start switch on the computer and by the clear signal generated by the UDCLR pulse.

The four signals that the program is concerned with are denoted T, B, C, and D. The B, C, and D signals are the digitized amplitudes of the energy loss in a series of 3 detectors in a telescope arrangement. The incident particle first goes through B, then C, then D. It is possible for the particle to stop in B or C or D but not to get through them all. The electronics are set up so as to give a constant energy loss per channel in each detector. Thus the sum of energy loss in the telescope is B + C + D. If only the first two detectors are penetrated, D = 0 so that the total energy loss is just B + C. The T signal is derived from the time that it takes for the particle to go from the target to the B detector. This information is of interest only if the particle stops in B so that signals are not available from C and D. Figure 1 is a schematic diagram of the 48 bits of input. For each 12 bit word the first bit (labeled OV) is an overflow bit. The bits labeled F1, F2, F3, etc are flag bits and the bits labeled D1, D2, D3, etc are data bits. The flag bits serve the following purposes:

F1 -- a coincidence flag which is set to one if the particle goes through the hole in the collimator and causes signals from both the B and the C detectors, Word 0 (T) Time of Flight [sometimes called (G) Garbage]

OV	F6	F4	F3	D1	D2	D3	D4	D5	D6	D7	D8

Word 1 (B) B Detector

OV	F2	F5	D1	D2	D3	D4	D5	D6	D7	D8	D9

Word 2 (C) C Detector

OV	F1	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Word 3 (D) D Detector

OV	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11

Fig. 1. Schematic Diagram of the Four Words for Each Event

F2 -- a coincidence flag which is set to one if the particle goes through the hole in the collimator and causes signals from the C and D detectors thus having passed through B and C and into D,

F3 -- a flag which the logic hardware sets to one for every event so that the programs can test that bit location in the data buffer to tell whether or not an event has been inputted,

F4 -- a pile-up indicator flag which is set to one whenever two or more events are recorded within 30 microseconds of each other and would cause an invalid signal,

F5 -- an extra flag which does nothing at the present time but may be used for some other purpose later,

F6 -- a flag which is set to one for pulser events which are fixed pulse-height pulses used for checking the stability of the system.

II. OPERATING INSTRUCTIONS

The normal starting address is location 200. The operating procedure for a normal start is as follows:

1. Start in location 200 -- computer halts,
2. key in code word for ID record and hit continue -- computer will write the ID record and halt again to give the operator a pause to think things over or change his mind,
3. hit continue -- computer will clear the two spectrum buffers, initialize the overflow channel markers and halt again to give the operator one last moment of reflection before letting signals come in through the data break,
4. hit continue -- computer clears the data buffer and starts taking data, writing the data on tape in 1000_8 word records and plotting or flickering data on the scope depending upon which option is specified in the key switches.

Other permissable starting locations for the FLICKERS system are:

372 a restart which gives the same effect as the execution of step three above,

373 a restart which flushes out the partially filled tape record buffer and then continues normal program operation (if no data is coming in then it simply keeps going through the anti-freeze loop),

377 a restart which gives the same effect as the execution of step 4 above,

120 an entry for independently plotting the contents of the spectrum buffers without data coming into the machine (the option switches should be set for options 1 or 2 since the other options would not be very interesting when no data is coming in),

130 an entry for continuously displaying a diagonal line across the scope for calibration purposes.

During execution the display option is determined by the contents of the key switches. The following options are available:

0. does nothing;
1. continuously plots the contents of the B + C buffer which contains the spectrum of the particles which are stopped in the C detector;
2. continuously plots the contents of the B + C + D buffer which contains the spectrum of the particles which are stopped in the D detector;
3. flickers for each event 2C vs (C+D)/2 with 1023_{10} dots full scale unless the event suffered one of the following disqualifications:
   a) overflow in C and/or D,
   b) 2C and/or (C+D)/2 exceeded 1023_{10},
   c) flag 2 was 0, i.e. no BCD coincidence,
   d) flag 4 was 1, i.e. pile-up flag was on;
4. flickers for each event 2B vs (B+C) with 1023_{10} dots full scale unless the event suffered one of the following disqualifications:
   a) overflow in B and/or C,
   b) 2B or (B+C) exceeded 1023_{10},
   c) flag 1 was 0 or flag 2 was 1, i.e. No BC coincidence or BCD coincidence as well as BC coincidence,
   d) flag 4 was 1, i.e. pile-up flag was on;
5. flickers for each event 2(B+C) vs (B+C+D)/2 with 1023_{10} dots full scale unless the event suffered one of the following disqualifications:

a) overflow in B, C, or D,
b) 2(B+C) or (B+C+D)/2 exceeded 1023_{10},
c) flag 2 was 0, i.e. no BCD coincidence,
d) flag 4 was 1, i.e. pile-up flag was on;

6. flickers for each event 4T vs 2B with 1023_{10} dots full scale unless the event suffered one of the following disqualifications:

a) overflow in T and/or B,
b) flag 2 was 1 or flag 1 was 1, i.e. either BCD or BC coincidence;

7. draws a box around the display area for scope calibration.

For the plotting options (1 and 2) the vertical scale is controlled by the typewriter. The operator should hit 0 to give full scale of 127_{10}, 1 to give full scale of 255_{10}, 2 to give full scale of 511_{10}, etc.

If an end of tape is encountered while the program is running the computer will stop after writing the current record. There will still be 14 feet of tape left and the operator should start at 200 and key in a 7777 ID code in step 2 above. When the computer again halts at the end of step 2 the operator can then remove the reel.

III. CORE STORAGE USED BY THE SUPER-FLICKERS SYSTEM

Locations	Contents
0010 -- 0012	Auto-index registers used by subroutine SAVED.
0020 -- 0062	Page 0 pointers and reference locations used for addressing across pages.
0070 -- 0076	Subroutine COMAND.
0120 -- 0125	Independent plot routine (INDPLOT).
0130 -- 0135	Straight line scope calibrating routine (SCOPECAL).
0140 -- 0156	Subroutine BBIAS.
0170 -- 0176	Subroutine INIT.
0200 -- 0366	Main routine of SUPER-FLICKERS system (FLICKERS).
0372 -- 0377	Restart entry points and invariant return locations for FLICKERS.
0400 -- 0472	Subroutine ERRCK.
0500 -- 0513	Subroutine SAVED.

0550 -- 0567	Subroutine BFCLR.
0600 -- 0760	The SYSPOP system of tape-popping routines (including subroutine WRITE).
1000 -- 1377	Data Buffer.
1400 -- 1553	Subroutine FLIC, options 1-4.
1600 -- 1725	Subroutine FLIC, options 5-7.
1736 -- 1777	Subroutine ANTFRZ (the anti-freeze subroutine).
2000 -- 2174	Subroutine SPEC (including subroutines ADD1 and INCR).
2200 -- 2272	Subroutine INTPLT.
2376 -- 2575	Spectrum overflow buffer.
2576 -- 3575	Tape record buffer.
3576 -- 5576	B+C spectrum for particles that stop in the C detector.
5577 -- 7577	B+C+D spectrum for the particles that stop in the D detector.

IV. PROGRAM DESCRIPTIONS

FLICKERS

FLICKERS is the main program of the SUPER-FLICKERS data acquisition system. It consists chiefly of a large loop which continually scans the data buffer for new data, transfers any new data that it finds to the tape record buffer, accumulates the spectrum of B+C for those particles which stop in the C detector and the spectrum of B+C+D for the particles which stop in the D detector, and jumps to the display routine (FLIC) to plot one of the spectrums or flicker the signals for the event depending upon the option specified in the key switches. In scanning the data buffer the program looks at every fourth location beginning with the first (location 1000) so that on a given pass it is looking to see if there is a T signal for a new event. If there is a new event then flag 3 (bit 3 of the T signal) will have been set to 1 by the logic hardware when the event was inputted. The program jumps to the anti-freeze subroutine (ANTFRZ) to check the flag. If ANTFRZ finds that flag 3 is 0 then it returns control back to the main program at a location that will send the main program back through the same procedure as before, looking at the same location in the data buffer, waiting for a new event to be inputted. If ANTFRZ finds that flag 3 is 1 it returns control to the main program in a location where the program will process the new event. The main program will then transfer the four words for the event to the tape record buffer, accumulate the event in the spectrum buffers, jump off to subroutine FLIC to flicker the event if a flicker option is specified by the key switches or refresh the plot of the spectrum if a plot option is specified, zero out the T-signal in the data buffer, add 4 to the program parameter (BMARK) which advances the scan through the data buffer so that the next pass through the loop will look for the next event, and subtract 4 from the up-down counter. The program will then jump to the bias checking routine (BBIAS) which checks all the events which stop in detector B (i.e. all those events for which both flag 1 and flag 2 are zero). If either flag 1 or flag 2 is 1 or if they are both 0 but the B signal exceeds the bias then the return from BBIAS is to a location which adds 4 to the program parameter EMARK so that the next event to be inputted will be transferred to the next 4 locations in the tape record buffer. If both flag 1 and flag 2 are 0 and the B signal was less than the bias then the return to the main program is to a location at the beginning of the loop and EMARK is not advanced so that the next event will be written over the event which was just transferred to the tape record buffer. In the former case (the more normal of the two), after advancing EMARK the program then checks to see if the tape record buffer has been filled up. If it has not been filled the program then jumps back to the beginning of the loop to start the whole process again. If the tape record is full the program jumps to subroutine WRITE (one of the subroutines in the SYSPOP tape system) to write the record on tape. For every eighth record that it writes the program jumps to subroutine ERRCK which reads the record back and compares it with the contents of the tape record buffer in order to check the operation of the tape unit.

After writing the record on tape (and perhaps checking it) the program clears the tape record buffer, sets EMARK to zero, jumps to subroutine FLIC to flicker the last event processed or refresh the spectrum plot (depending on the option specified in the key switches), and checks to see if a new scaling constant for plotting has been typed into the keyboard. If no new scaling constant has been typed in, it returns to the beginning of the loop to start the process again. If a new scaling constant has been typed in, the program jumps off to subroutine COMAND to read it and store it away in the plotting routine (INTPLT) before returning to the beginning of the loop.

There are several starting entries for FLICKERS which cause the program to carry out various tasks before entering the main loop described in the preceding paragraph. A description of these entries and what the program does when they are used is given in section II.

ANTFRZ

ANTFRZ is the subroutine which FLICKERS uses to test a T-signal location in the data buffer to see if it contains an event to be processed. ANTFRZ is called with the contents of the T-signal location in the AC. ANTFRZ checks the flag 3 position of this actual or potential T-signal. If it finds a 1 in this flag 3 bit then there is an event to be processed and ANTFRZ returns to a location in FLICKERS which starts the processing. If flag 3 is 0 then there is no event to be processed and ANTFRZ counts up a counter which overflows on a count of $40,000_8$ and, if there is no overflow, returns to the main program at the beginning of the main loop, first jumping to FLIC if a plot option is specified in the switch register. If there is an overflow ANTFRZ rings the bell on the teletype, resets the counter to 0 and returns control to FLICKERS in a location which causes the program to clear the data buffer and the tape record buffer before going back to the beginning of the main loop.

INIT

INIT is a subroutine called by FLICKERS in the normal starting procedure, before entering the main loop, to initialize the teletype keyboard and the teleprinter and to set the scope to maximum brightness level.

COMAND

COMAND is a subroutine called by FLICKERS when it receives a signal typed in from the teletype keyboard. COMAND converts the signal from an ASCII code to an octal integer and stores the result in the scaling constant location in the integrating plot routine (INTPLT). It then returns control to the main program.

BBIAS

BBIAS is a subroutine which is called by FLICKERS to set a threshold of acceptance for the events corresponding to particles which stop in the B detector. If either flag 1 or flag 2 is 1 then the particle penetrated to the C or D detector and BBIAS gives a normal return to FLICKERS. If both flag 1 and flag 2 are 0, the particle stopped in the B detector and BBIAS checks the B signal against a tolerance level which is set by a parameter in the program. If the B signal exceeds the tolerance then BBIAS gives a normal return to FLICKERS but if the signal does not exceed the bias then BBIAS gives a return which skips the section of FLICKERS which advances the tape record buffer marker EMARK so that the data for the next event will be written over the data for the present event thus effectively discarding the current event.

ERRCK

ERRCK is a subroutine called by FLICKERS to check every 8th record which it writes on tape. ERRCK is called immediately after the record is written. It backspaces the tape over the record and then reads the record comparing each word that it reads with the corresponding word in the tape record buffer. If it detects a discrepancy between the word on tape and the corresponding word in the buffer, or if it detects a size error (the tape record being more than or less than 1000_8 words), or if it detects a parity error, then ERRCK prints an "E" on the teleprinter before returning control to FLICKERS.

SAVED

SAVED is a subroutine called by FLICKERS to transfer the four words for each event to the tape record buffer and to mask off the flags from the four words and store the resulting "trimmed" signals in locations on page 0 that can be easily referenced by other programs in the system which need the trimmed signal (e.g. FLIC). SAVED uses the auto-indexing locations 0010, 0011, and 0012 and is called four times successively by FLICKERS, once for each word of the event. It also uses locations 0047, 0050, 0051, ..., 0062 in the following manner:

Loc.	Name	Use
0047	TNAT	Location for storing the untrimmed T signal,
0050	TMASK	Mask for trimming the T signal (0377),
0051	TTR	Location for storing the trimmed T signal,
0052	BNAT	Location for storing the untrimmed B signal
0053	BMASK	Mask for trimming the B signal (0377),
0054	BTR	Location for storing the trimmed B signal,
0055	CNAT	Location for storing the untrimmed C signal,
0056	CMASK	Mask for trimming the C signal (1777),
0057	CTR	Location for storing the trimmed C signal,
0060	DNAT	Location for storing the untrimmed D signal,
0061	DMASK	Mask for trimming the D signal (3777),
0062	DTR	Location for storing the trimmed D signal.

The first time SAVED is called by FLICKERS, location 0010 should contain BUFFAD-1 where BUFFAD is the address in the data buffer of the T signal for the event being processed. Location 0011 should contain TRBUFP+EMARK-1 where TRBUFP is the address of the first location in the tape record buffer and EMARK is the program parameter which gives the location in the tape buffer for storing the T signal. Location 0012 should contain TNAT-1 (0046). SAVED uses location 0010 to pick up the T signal from the data buffer and location 0011 to store it away in the tape record buffer. In the process the auto-indexing feature of these two locations causes them to be incremented by 1 so that the next time SAVED is called they are set to transfer the B signal, and the next time after that they are set to transfer the C signal, and the last time they are set to transfer the D signal. Similarly, each time it is called, SAVED uses location 0012 to store the untrimmed signal, pick up the mask for trimming the signal, and store the trimmed signal and in the process the auto-indexing feature sets the location for the next signal. After SAVED has been called four times successively the event will have been transferred to the tape record buffer and locations 0051, 0054, 0057, and 0062 will contain the T, B, C, and D signals trimmed of all the flags for the event and ready to be used as such other programs in the SUPER-FLICKERS system.

BFCLR

BFCLR is a subroutine called several times by FLICKERS to clear various blocks of core storage (e.g. the data buffer). The calling sequence for BFCLR is:

```
JMS I BFCLRP
XXXX
YYYY
(CONTINUE)
```

where BFCLRP is a location containing the address of the first location of BFCLR (550), XXXX is the address of the first location in the block to be cleared, and YYYY is the number of words to clear. When it is called, BFCLR stores zeroes in the block specified in the calling sequence and then returns control to the calling program.

THE SYSPOP TAPE SYSTEM

SYSPOP is a system of 4 subroutines for reading, writing, rewinding, and spacing the magnetic tape. These 4 subroutines are called REWIND, RECSKP, WRITE, and READ. At the present time the SUPER-FLICKERS system uses only subroutine WRITE but all of them will be described here so they can be used in future data acquisition programs.

REWIND is a subroutine which can be called to rewind the tape. The calling sequence for REWIND is:

```
JMS I REWP
(CONTINUE)
```

where REWP is a location containing the address of the first location in REWIND (0600). When it is called, REWIND waits until the tape is ready, initiates the rewind, waits until the rewind is completed and then returns to the calling program.

RECSKP is a subroutine that can be called to skip over a specified number of records on the tape. It can skip either forward or backward depending on the calling sequence which is as follows:

```
CLL (STL)      /FOR SKIPPING FORWARD (BACKWARD)
JMS I RSKPP
XXXX
(CONTINUE)
```

where RSKPP is a location containing the address of the first location of RECSKP (0602), and XXXX is the number of records to skip. When it is called, RECSKP waits until the tape is ready, skips the specified number of records, stops the tape motion after the last record is skipped, and returns control to the calling program.

WRITE is a subroutine which is called to write a continuous block of storage as a record on tape. The calling sequence is:

```
        JMS I WRITEP
        XXXX
        YYYY
        (CONTINUE)
```

where WRITEP is a location containing the address of the first location of WRITE (0604), XXXX is the address of the first location to write and YYYY is the number of words to write (the length of the record to write). When it is called, WRITE waits until the tape is ready, writes the block specified in the calling sequence as a record on tape, stops the tape when the writing is finished, and checks to see if an End of Tape was detected while writing the record. If no End of Tape was encountered then it returns control to the calling program but if an End of Tape was encountered then WRITE does not return to the calling program but instead halts with 4444 in the accumulator.

READ is a subroutine which can be called to read a record from tape into a continuous block of storage. The calling sequence is:

```
        JMS I READP
        XXXX
        YYYY
        (CONTINUE)
```

where READP is a location containing the address of the first location of READ, XXXX is the address of the first location to read into, YYYY is the number of words in the record being read. When it is called, READ waits until the tape is ready, reads the record into the storage block specified in the calling sequence, checking for errors at the same time, and if it successfully reads the record without any errors it returns control to the calling program. If there is an error then READ will give one of the following error stops:

1. A stop with 7777 in the AC indicates a size error and means that the record on tape was either larger than or smaller than the number specified in the calling sequence,
2. A stop with 1111 in the AC means that the block of storage specified in the calling sequence overlapped the top of core (and among other things, this means that the RIM loader was probably destroyed),
3. A stop with 2222 in the AC indicates a parity error.

Potential users of READ may want to change some of the error stops described above so that the program tries again after failure.

All four of the subroutines described above use a subroutine called READY to wait until the tape is ready. When it is called, READY continually looks at the "Transport is Ready" bit of the Tape Status Register and when the ready condition is satisfied it returns control to the calling program.

FLIC

FLIC is a subroutine called by FLICKERS to flicker the event currently being processed or to plot one of the spectrum buffers. The present version of FLIC has 7 options corresponding to 7 different tasks which FLIC can perform. When it is called,FLIC picks up the number in the switch keys, masks it with the number 0007_8 and uses the result to determine which option it performs. If the result is 0000, FLIC simply returns to the calling program without doing anything. Options 1 through 7 are described below:

Option Action

1 Each time it is called with option 1 specified, FLIC plots the next consecutive channel in the B+C spectrum of particles which stopped in the C detector. Since the derivative of the spectrum rather than the spectrum itself is what subroutine SPEC accumulates in the spectrum buffer, FLIC jumps off to an integrating plot routine (INTPLT) to compute and plot the channel. Since it only plots one channel each time it is called, FLIC must be called continually to maintain the plot of the spectrum.

2 Option 2 is a plot option just like option 1 except that it plots the B+C+D spectrum of particles which stopped in the D detector.

3 When option 3 is specified, FLIC flickers the event currently being processed by the main program provided Flag 2 is 1 (i.e. the particle penetrated to the D detector). It intensifies a spot on the oscilloscope screen whose X-coordinate is (C+D)/2 and whose Y-coordinate is 2C. If the particle did not penetrate to the D detector, or if there is an overflow in C or D, or if either the X- or Y-coordinate exceeds 1023_{10}, FLIC returns control to the calling program without plotting anything.

4 For option 4 FLIC flickers the events which stop in the C detector. It intensifies a spot with X-coordinate (B+C) and Y-coordinate 2B unless there is an overflow in B or C or unless 2B or (B+C) exceeds 1023_{10} in which case it returns to the calling program without plotting anything. It also returns without plotting if Flag 1 is 0 (the particle did not reach the C detector), if Flag 2 is 1 (the particle penetrated to the D detector), or if the pile-up flag is on.

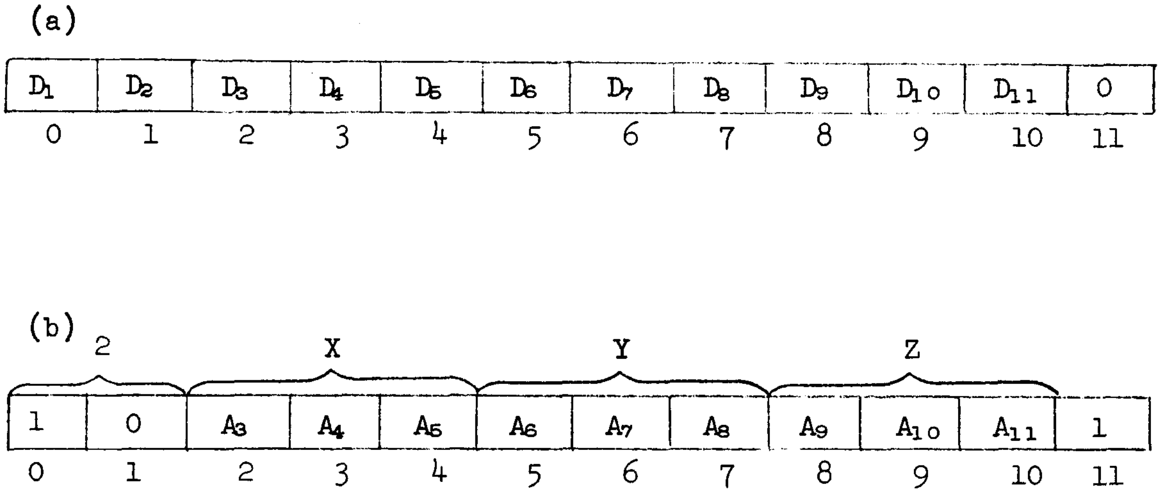
5 For option 5 FLIC flickers a spot with X-coordinate (B+C+D)/2 and Y-coordinate 2(B+C) provided the particle reached the D detector and provided there is no overflow in B, C, or D. If the particle failed to reach the D detector, or if there is an overflow in B, C, or D or if either the X- or Y-coordinate exceeds 1023_{10}, or if the pile-up flag is on, then FLIC return to the calling program without plotting anything.

6 Option 6 is an option for flickering the events for particles which stopped in the B detector. If both Flag 1 and Flag 2 are 0 then FLIC will intensify a point with X-coordinate 2B and Y-coordinate 4T provided there is no overflow in B or T. If this last condition is not satisfied then FLIC returns to the main program without plotting anything.

7 Option 7 causes FLIC to "draw" a box around the display area so that the user can calibrate the scope.

SPEC

SPEC is the subroutine which is called by FLICKERS to accumulate in the two spectrum buffers the derivatives of the two spectrums. The derivatives rather than the spectrums themselves are accumulated since a 12-bit word is not large enough to accomodate the number of counts that will be accumulated in many of the channels during the course of a run (the maximum number which can be expressed by 12 bits is 4095_{10}). In accumulating the derivative of the spectrum it is necessary to store in each channel location the difference between the number of counts in that channel and the number of counts in the preceding channel. Since this difference can be negative the numbers which are accumulated must be thought of as signed integers. With a 12-bit word this would normally allow the difference to lie anywhere between -2047_{10} and $+2047_{10}$, but since in the peaks of the spectrum the difference between two adjacent channels may exceed 2047_8 in absolute value some provision had to be made for channels which overflow in this manner. This was done by reserving one bit in the word as an overflow indicator and this left 11 bits for expressing the difference. Figure 2a is a schematic diagram of the typical channel location which has not suffered an overflow. Bits 0-10 constitute the two's complement representation of a number in the range between -1023_{10} and 1023_{10} inclusive. Bit 11 is the overflow indicator bit and is equal to 0 for a channel difference which has not suffered an overflow. To subtract one from the channel difference one simply adds 7776 and to add one to the difference one adds 0002. In both cases the overflow bit is left unchanged. If the result of such a subtraction or addition ever produces 4000 as a result then the subtraction or addition has caused an overflow and the channel location becomes a overflow location. Figure 2b illustrates such an overflow location. Bit 11 is set to one to indicate the overflow condition and bits 0-10 contain the address in the overflow buffer of the low order word of a double precision pair of words in which the overflowed channel difference is stored. The overflow buffer is located in locations 2376-2575 and any number in this range is



$$2376 \leq 2XYZ \leq 2575$$

Fig. 2. Schematic Diagram of Typical Channel Locations in the Spectrum Buffers when (a) the channel difference has not overflown and (b) when the channel difference has overflown.

expressible in the 11 bits allotted. When SPEC is called it accumulates the event currently being processed in the B+C+D buffer if Flag 2 is 1 and in the B+C buffer if Flag 2 is 0 and Flag 1 is 1. If both Flag 1 and Flag 2 are 0 but the pulser flag is on then SPEC accumulates the event in the B+C+D buffer. If both Flag 1 and Flag 2 are 0 and the pulser flag is 0 also then SPEC returns control to FLICKERS without accumulating the event. SPEC also returns without accumulating if the pile-up flag is on, if there is an overflow in B, C, or D or, in the case where Flag 2 is 1, if (B+C+D)/2 exceeds 1777_8. To do the actual accumulating SPEC calls subroutine ADD1 which is described below.

ADD1

ADD1 is the subroutine called by SPEC to accumulate an event in one of the spectrum derivative buffers. If the event is to be accumulated in the B+C buffer then SPEC is called with the AC containing the address in the B+C buffer of the channel location corresponding to the channel being incremented. ADD1 then adds 1 to that channel location since the addition of a count in that channel will increase its difference from the preceding channel by one. ADD1 also subtracts 1 from the succeeding channel location since adding a count to any channel decreases by one the difference between the succeeding channel and the channel in question. If the event is to be accumulated in the B+C+D buffer then ADD1 is called with the AC containing the channel location in the B+C+D buffer of the channel being incremented. ADD1 calls subroutine INCR to do the actual adding and subtracting. It should be noted that each of the two buffers contains 2001_8 locations and can accomodate 2000_8 channel locations (the extra location in each case is a dummy location at the end of the buffer to give the program a location to subtract from for counts which go into the highest channel). But the quantities B+C and B+C+D can exceed 2000_8. Therefore the sums B+C and B+C+D are divided by 2 to determine the actual channel numbers used in the spectrum buffers.

INCR

INCR is the subroutine called by ADD1 to do the actual adding to or subtracting from a given channel location. INCR is called with a program parameter (TEMP) containing the address in the spectrum buffer of the channel location to be incremented or decremented. It is called twice by ADD1 -- the first time to add 1 to the channel location corresponding to the channel receiving the new count and the second time to subtract one from the succeeding channel location. The calling sequence for adding 1 is:

```
JMS INCR
0002
(CONTINUE),
```

and the calling sequence for subtracting 1 is:

```
JMS INCR
7776
(CONTINUTE).
```

When it is called INCR checks to overflow bit of the channel location and if it is not a overflow channel adds the increment (0002 or 7776) and then if that did not cause an overflow it returns control to ADD1. If adding the increment does cause an overflow then INCR stores the overflowed result as a double precision channel location in the next 2 available words in the overflow buffer, stores the address of the low order word of that double precision pair in bits 0-10 of the original channel location, sets the overflow bit (bit 11) of the original location to 1 and returns control to ADD1. If the channel location was already an overflow location when INCR was called then INCR adds the increment to the double precision locations in the overflow buffer whose low order address is specified in bits 0-10 of the channel location and then returns control to ADD1. Users of the FLICKERS system should keep in mind that the overflow buffer contains 200_8 locations and hence can accomodate only 100_8 overflows. There is no provision in INCR for checking the number of overflows and it is conceivable that if a spectrum were especially jagged and if the experimental run were long enough then the overflows might overflow the overflow buffer and INCR might start using locations in the tape record buffer (which follows the overflow buffer in core) as overflow locations. The guiding philosophy in writing INCR was that such an occurence was very unlikely in a normal experimental run but a dubious user might want to build some protection for the tape buffer into INCR. This might possibly be done by just keeping a count of the overflows and stopping the program when the count reaches 100_8.

INTPLT

INTPLT is a subroutine called by FLIC to integrate the derivative of the spectrum stored in one of the spectrum buffers and to plot the spectrum thus obtained on the oscilloscope. INTPLT must be called once for each channel that it plots. Therefore it must be called continuously to maintain a plot of a spectrum. INTPLT should be called with the AC containing the beginning address of the buffer being plotted. INTPLT adds to this address a program parameter COUNT to get the address of the channel to be plotted. Each time it is called INTPLT uses COUNT to determine the X-coordinate of the plot (the channel number) and the location in the spectrum buffer of the channel location corresponding to that channel. It also increases COUNT by 1 so that the next time it is called it will plot the next channel. Whenever COUNT reaches 2000_8 (1024_{10}) INTPLT sets COUNT back to 0 to begin the next sweep through the buffer and across the scope. As it sweeps through the buffer INTPLT maintains a double precision sum of all the channel differences that went before and hence has the contents of the channel currently being plotted. Thus any time INTPLT is called this double precision sum will contain the number of counts in the last channel plotted and INTPLT will add to this the channel difference corresponding to the next channel in the buffer. The result is just the number of counts in the channel currently under consideration and INTPLT uses this, subject to scaling by a scaling constant, as the Y-coordinate of the plot. When the end of a sweep is reached INTPLT sets the double precision sum to 0 for the next sweep.

INDPLOT

INDPLOT is an independent program which can be used to plot a spectrum when nothing else is happening. It consists simply of a loop which continually calls FLIC and jumps to COMAND to pick up any new scaling constant that might be typed in by the user.

SCOPECAL

SCOPECAL is an independent program which continually plots a diagonal line which can be used in calibrating the scope.

ORNL DWG 67-6407

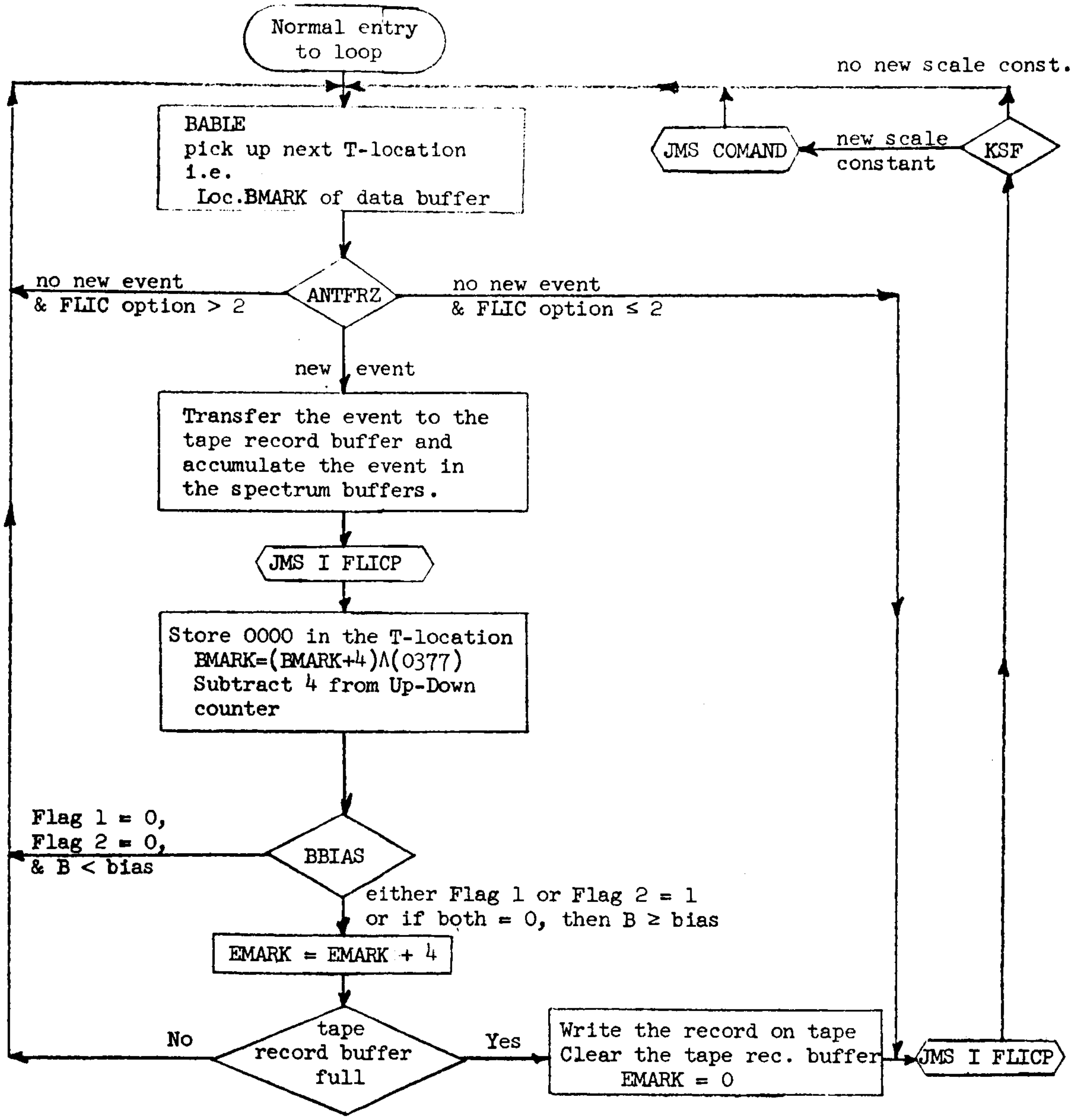
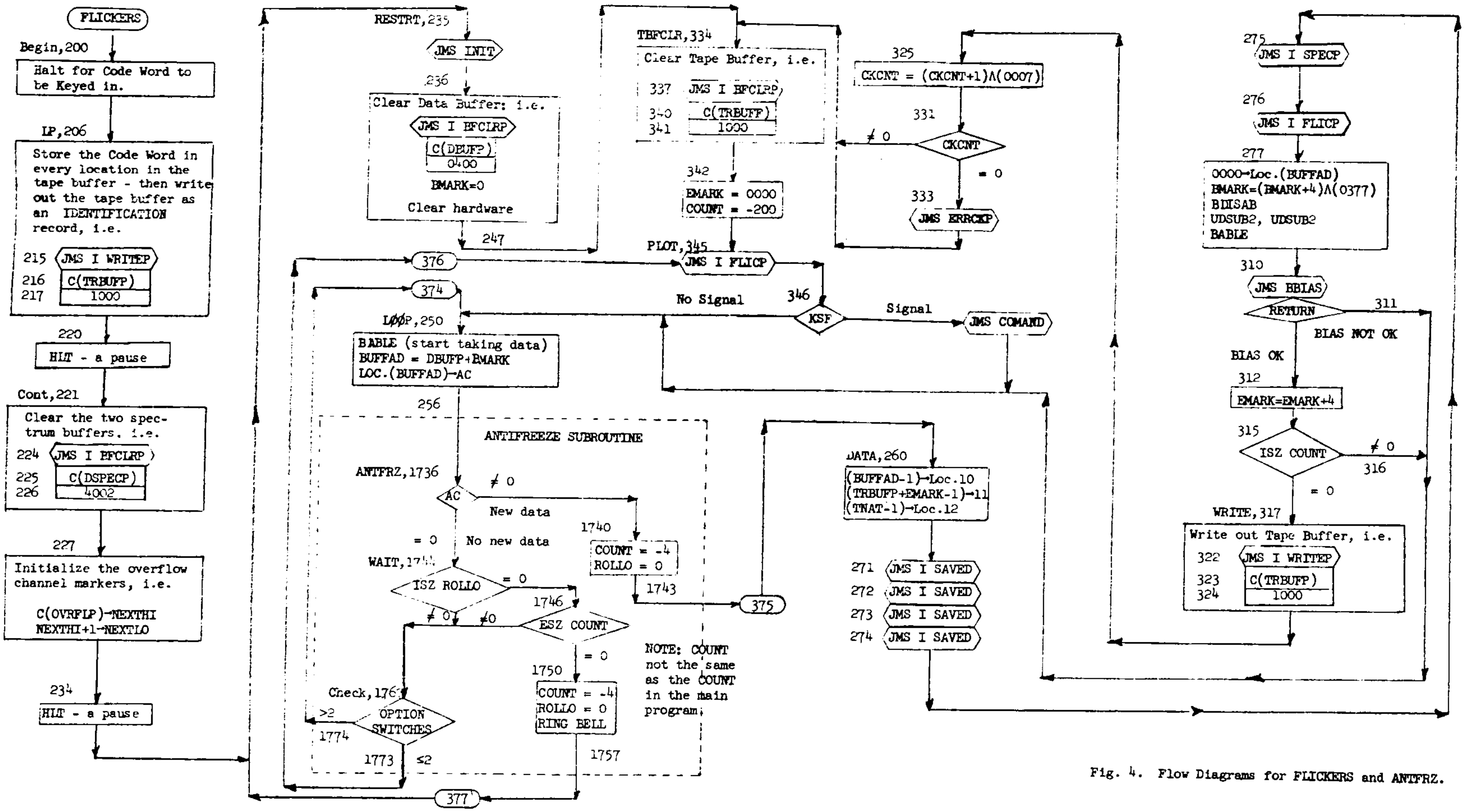


Fig. 3. Abbreviated Flow Diagram of Main Loop in FLICKERS (does not show the overflow branch from ANTFRZ).



ORNL DWG 67-6408

Fig. 4. Flow Diagrams for FLICKERS and ANTFRZ.

ORNL DWG 67-6409

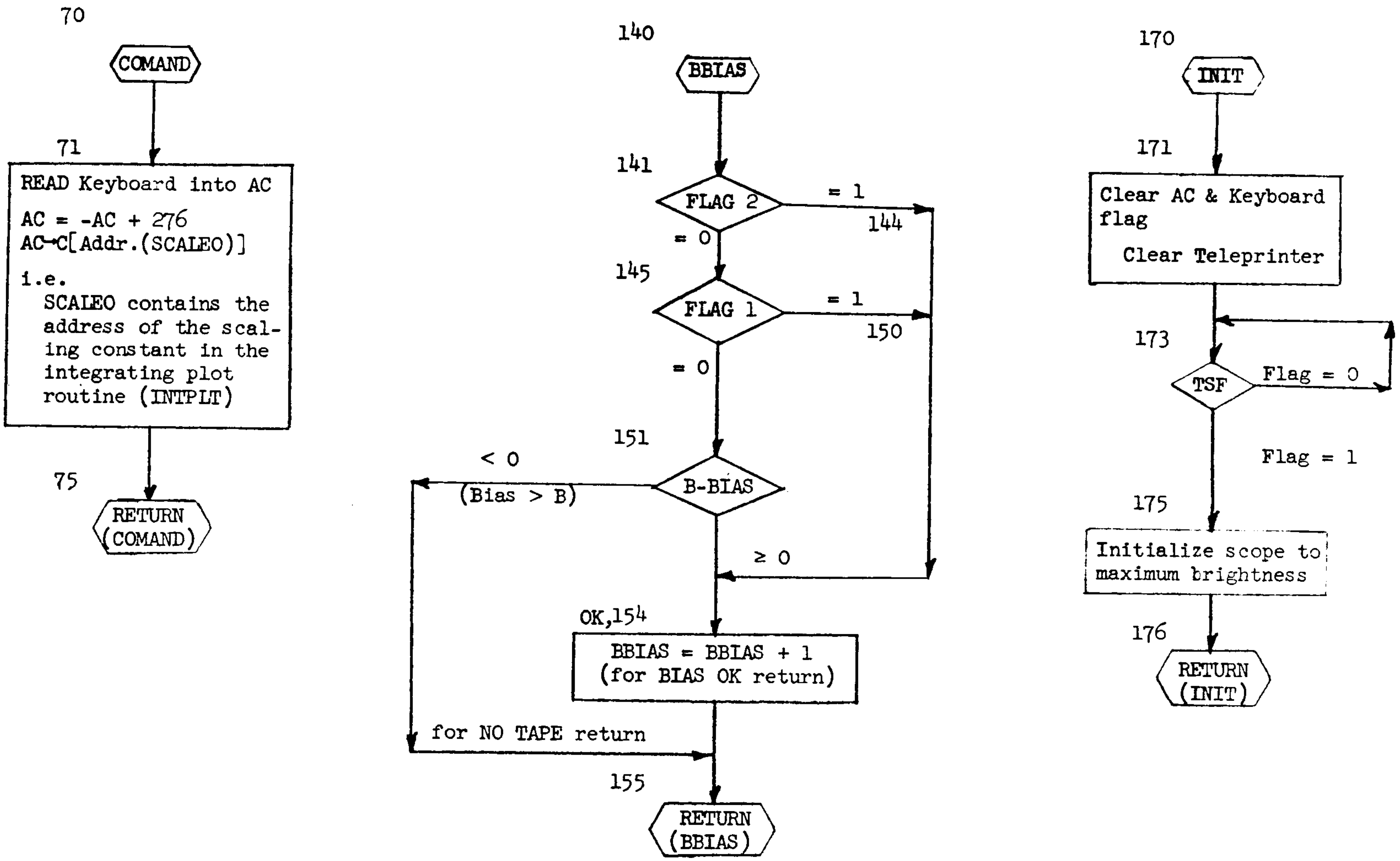


Fig. 5. Flow Diagrams for COMAND, BBIAS, and INIT.

ORNL DWG 67-6410

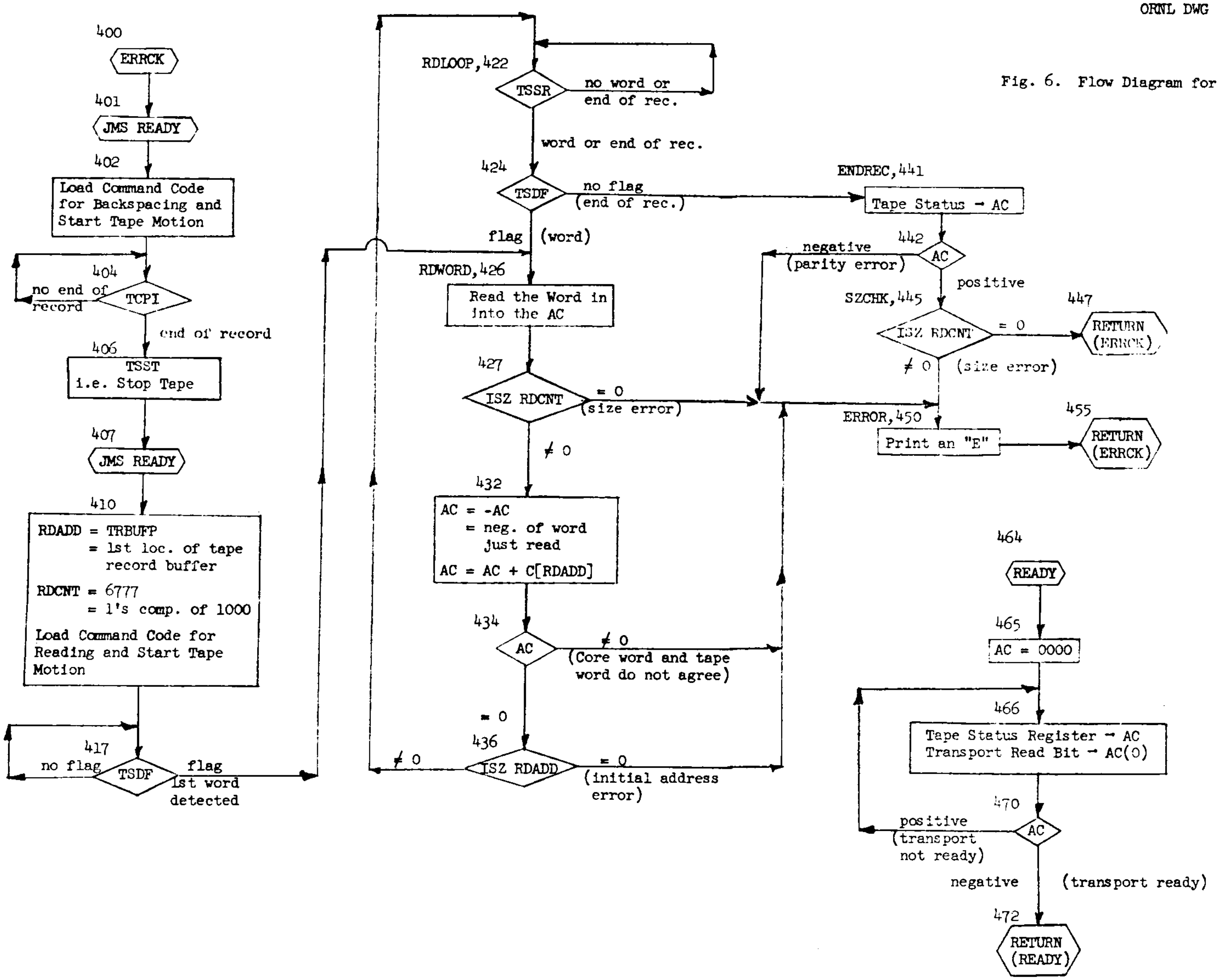
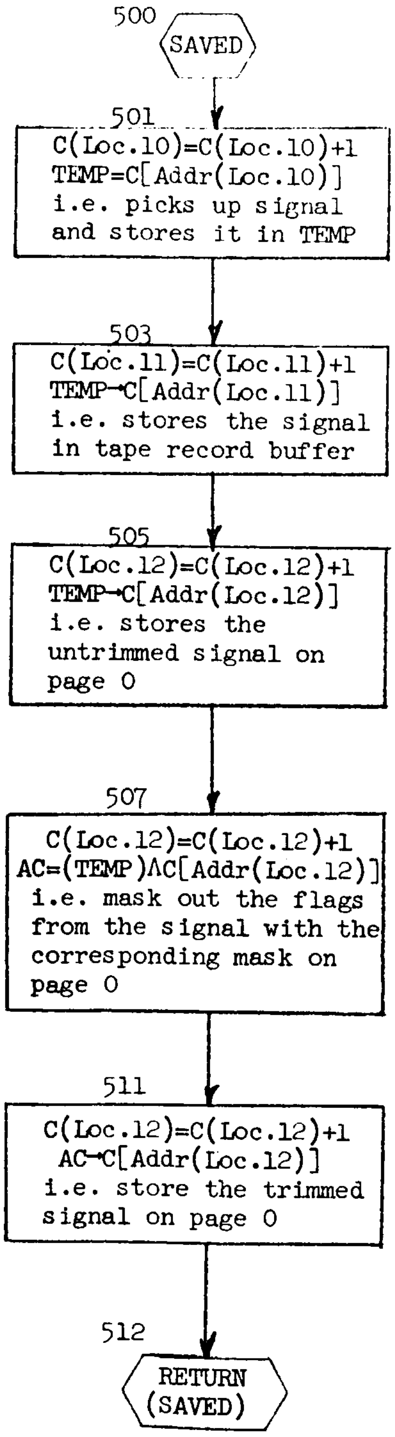


Fig. 6. Flow Diagram for ERRCK

ORNL DWG 67-6411



NOTE: SAVED IS CALLED 4 TIMES SUCCESSIVELY FOR EACH EVENT. THE FIRST TIME IT IS CALLED, THE AUTO-INDEXING LOCATIONS 10, 11, 12 WILL HAVE CONTENTS AS FOLLOWS:

C(Loc.10) = BUFFAD-1
where BUFFAD is the address in the data buffer of the first (T) signal for the event.

C(Loc.11) = TRBUFP+EMARK-1
where TRBUFP+EMARK is the address in the tape record buffer for the signal.

C(Loc.12) = TNAT-1
where TNAT is the address on page zero of the first location in the following block (Locs. 47-62)

47, TNAT ≡ Loc. for storing untrimmed T-signal
50, TMASK ≡ Loc. of mask for trimming T-signalk
51, TTR ≡ Loc. for storing trimmed T-signal
52, BNAT ≡ etc.,
53, BMASK ≡ etc.,
54, BTR ≡ etc. for B-signal,
55, CNAT ≡ and
56, CMASK ≡ for
57, CTR ≡ C-signal,
60, DNAT ≡ and
61, DMASK ≡ for
62, DTR ≡ D-signal.

Fig. 7. Flow Diagram for SAVED

ORNL DWG 67-6412

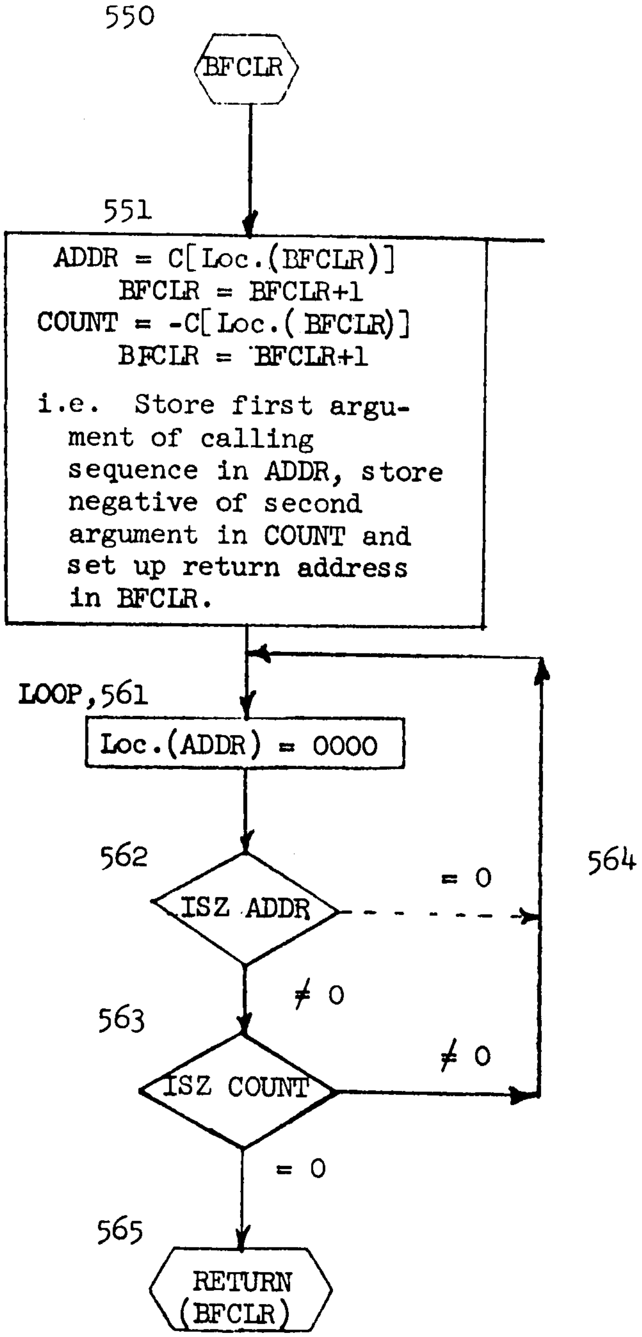


Fig. 8. Flow Diagram for BFCLR

ORNL DWG 67-6413

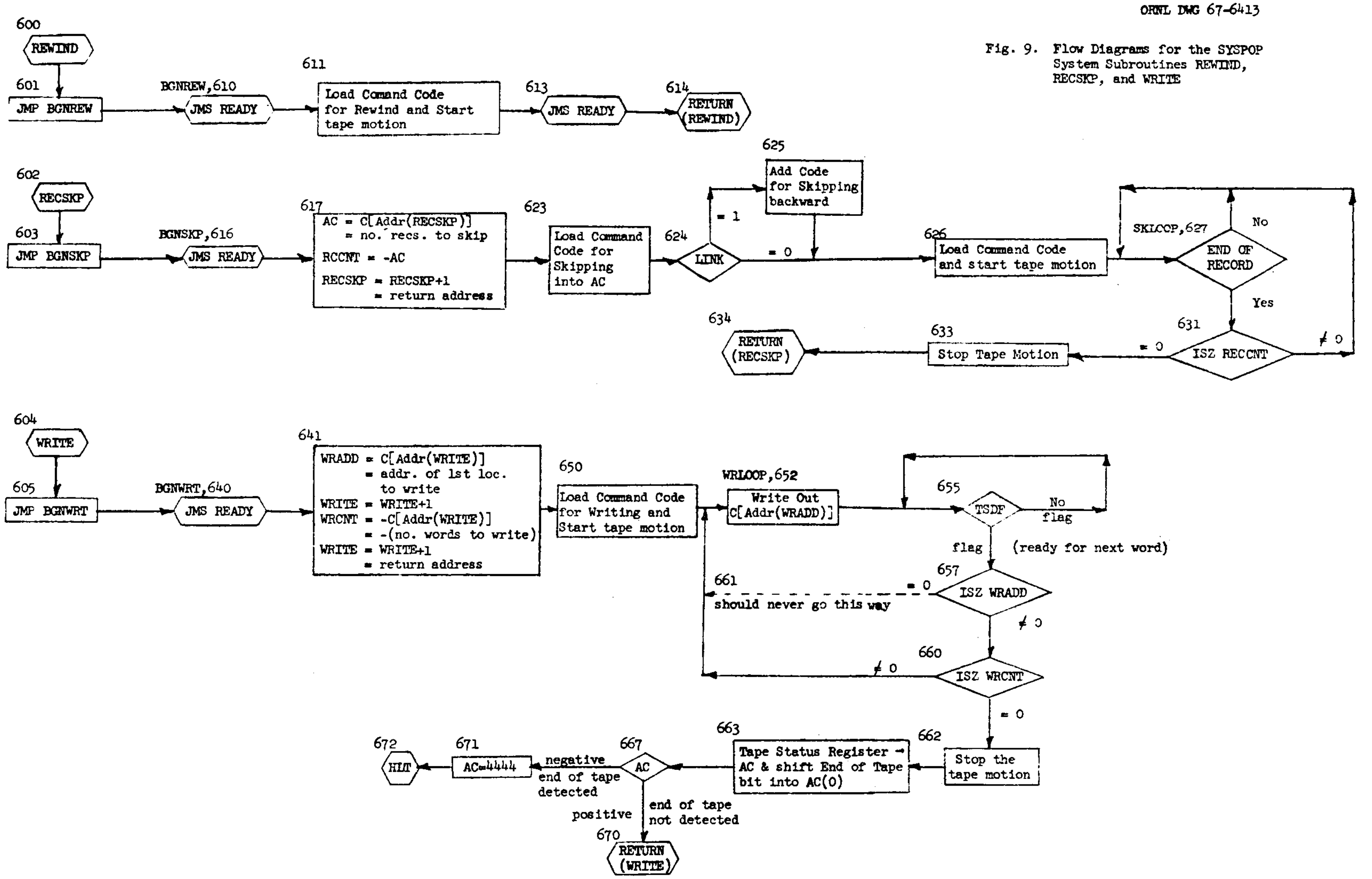


Fig. 9. Flow Diagrams for the SYSPOP System Subroutines REWIND, RECSKP, and WRITE

ORNL DWG 67-6414

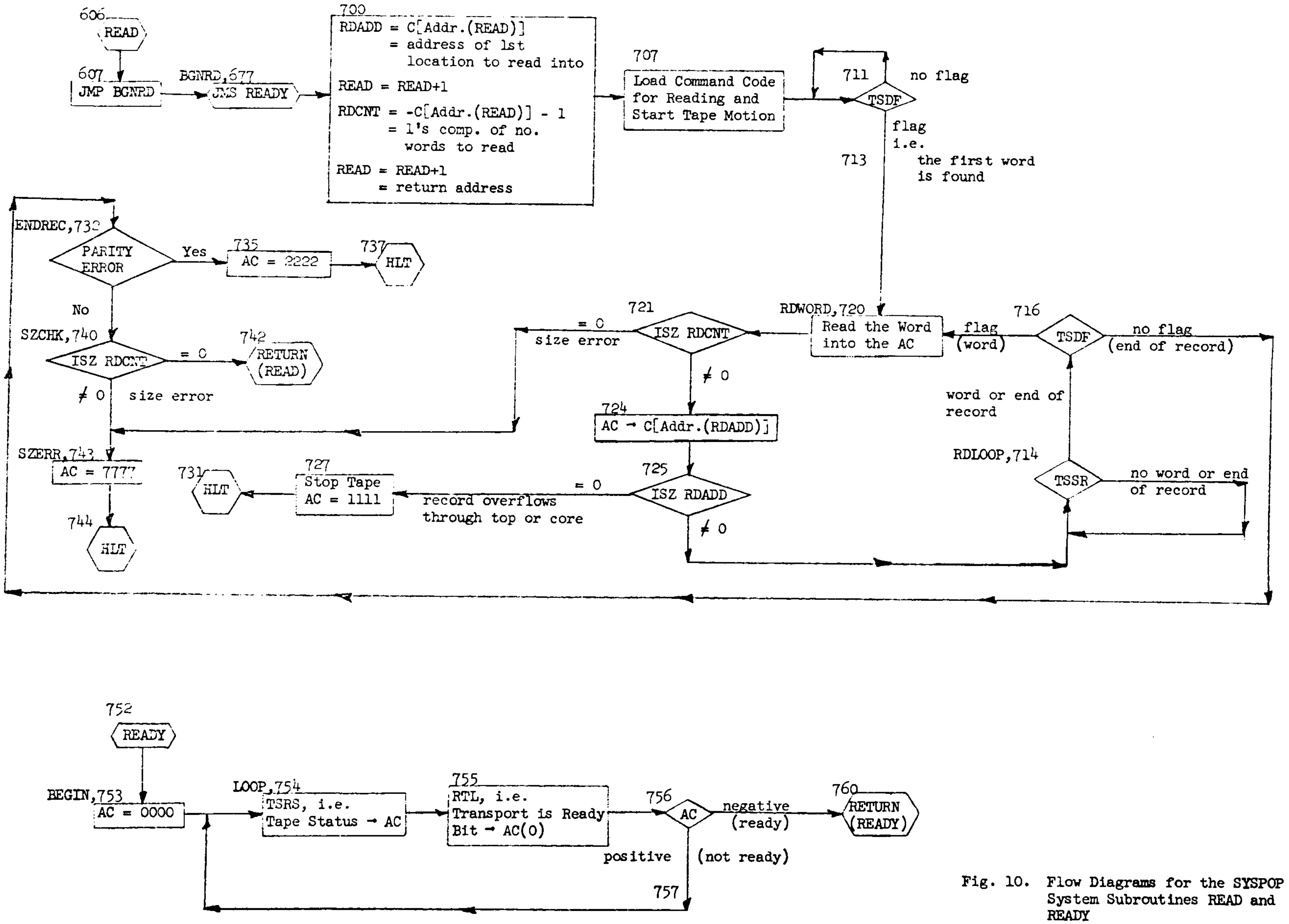


Fig. 10. Flow Diagrams for the SYSPOP System Subroutines READ and READY

ORNL DWG 67-6415

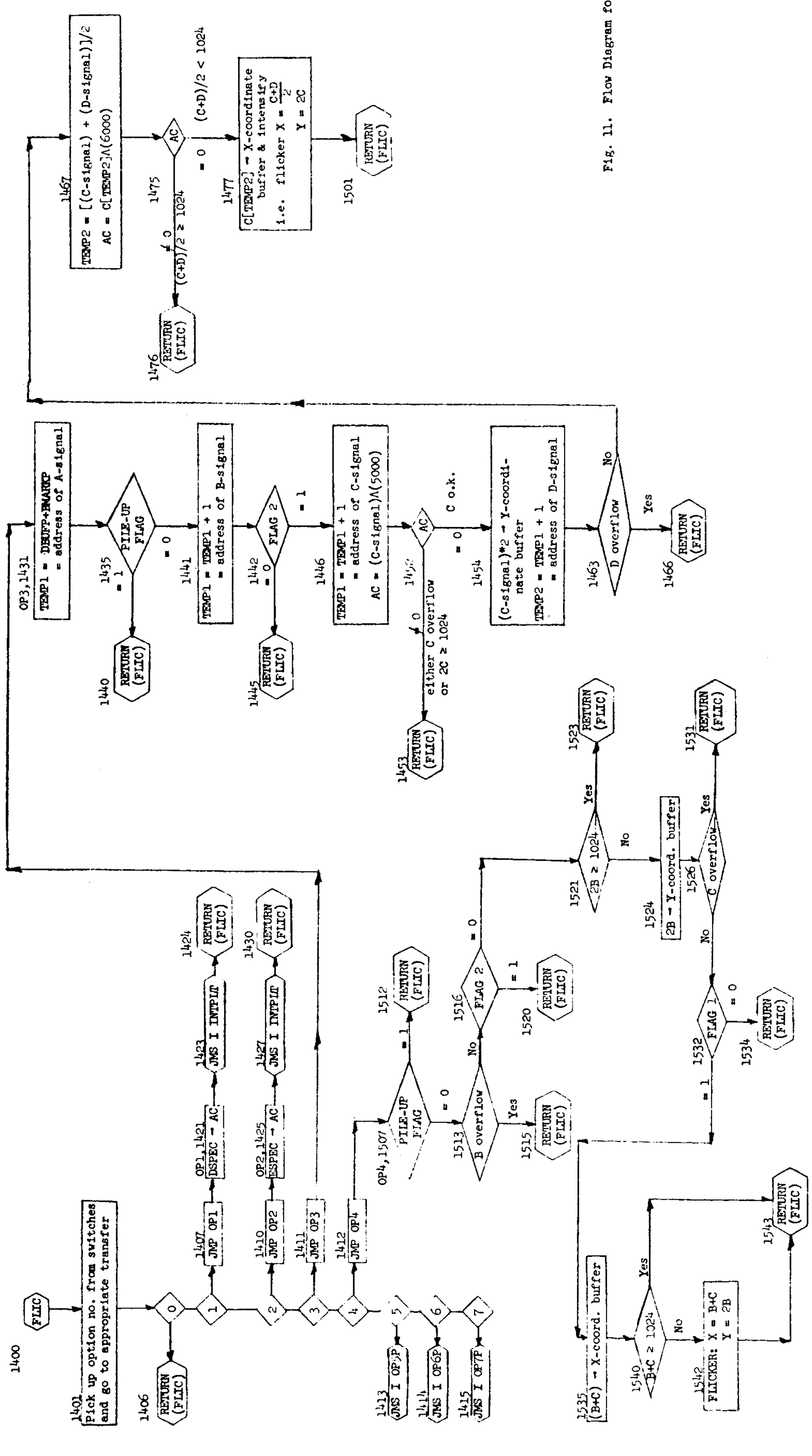


Fig. 11. Flow Diagram for FLIC

ORNL DWG 67-6416

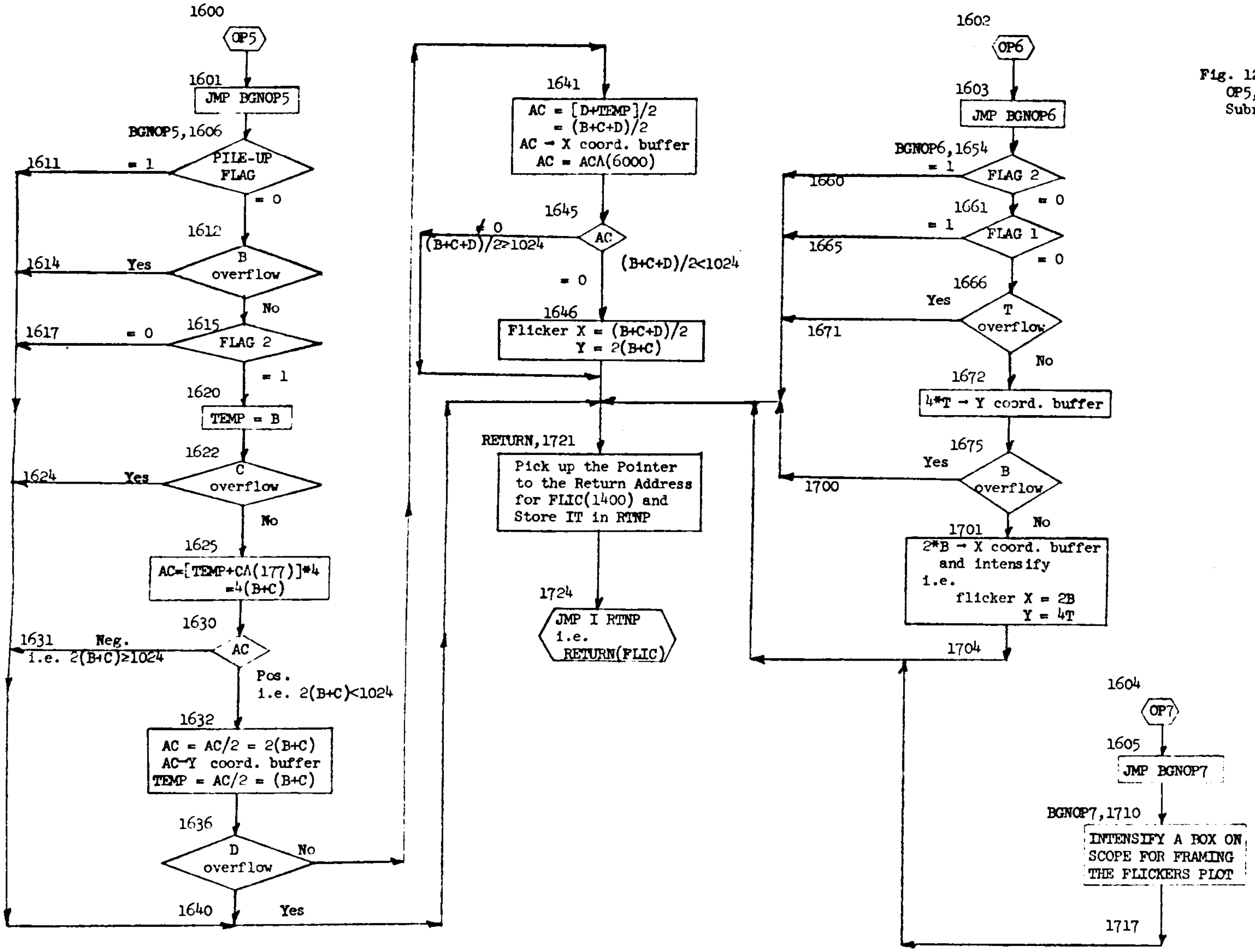


Fig. 12. Flow Diagrams for OP5, OP6, and OP7 - Subroutines for FLIC.

ORNL DWG 67-6417

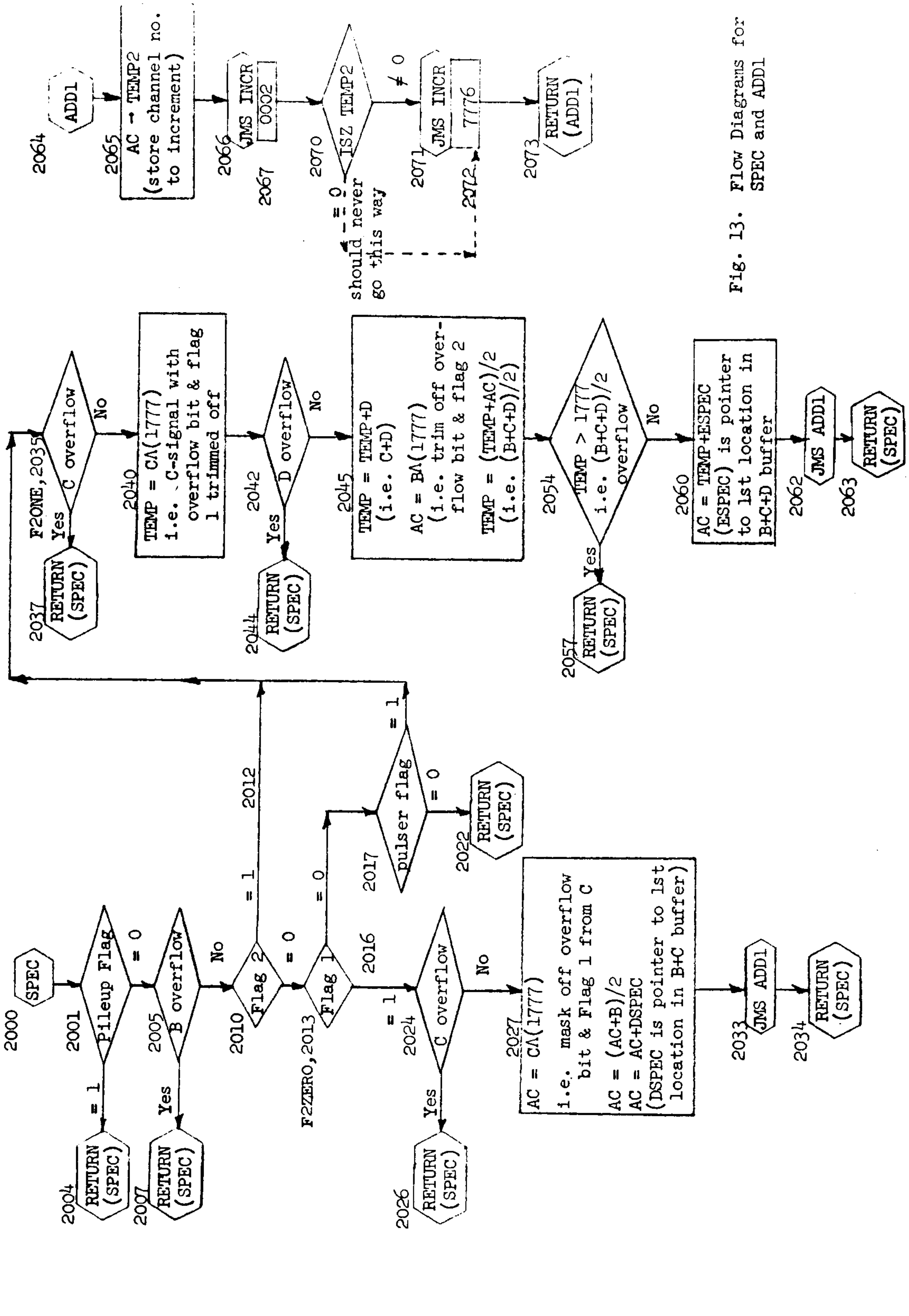


Fig. 13. Flow Diagrams for SPEC and ADD1

ORNL DWG 67-6418

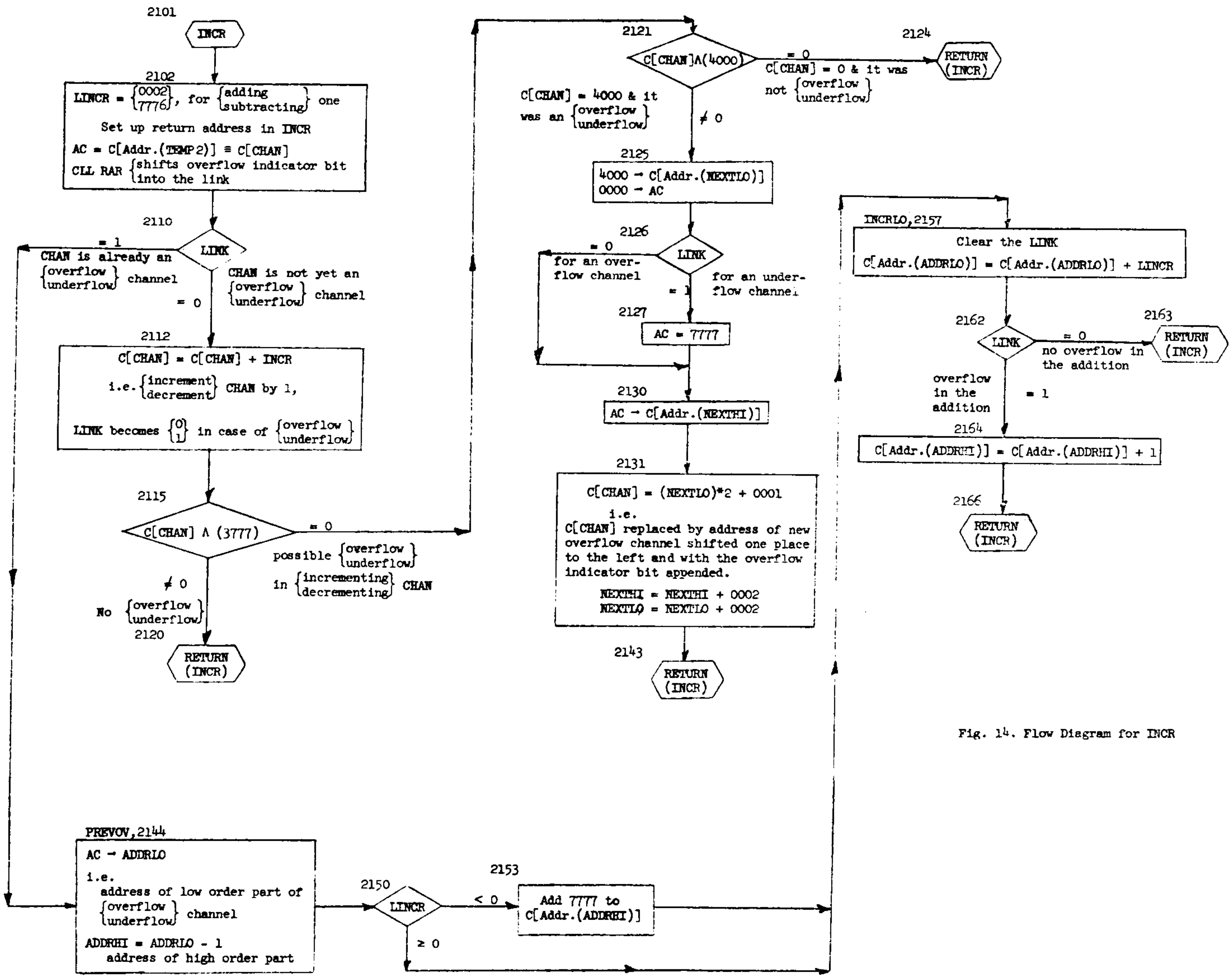

2101
INCR
2102
LINCR = {0002 / 7776}, for {adding / subtracting} one
Set up return address in INCR
AC = C[Addr.(TEMP2)] ≡ C[CHAN]
CLL RAR {shifts overflow indicator bit / into the link
2110
LINK
= 1
CHAN is already an {overflow / underflow} channel
= 0
CHAN is not yet an {overflow / underflow} channel
2112
C[CHAN] = C[CHAN] + INCR
i.e. {increment / decrement} CHAN by 1,
LINK becomes {0 / 1} in case of {overflow / underflow}
2115
C[CHAN] ∧ (3777)
= 0
possible {overflow / underflow}
in {incrementing / decrementing} CHAN
≠ 0
No {overflow / underflow}
2120
RETURN (INCR)
2121
C[CHAN]∧(4000)
= 0
C[CHAN] = 0 & it was not {overflow / underflow}
2124
RETURN (INCR)
C[CHAN] = 4000 & it was an {overflow / underflow}
≠ 0
2125
4000 → C[Addr.(NEXTLO)]
0000 → AC
2126
LINK
= 0
for an over-flow channel
= 1
for an under-flow channel
2127
AC = 7777
2130
AC → C[Addr.(NEXTHI)]
2131
C[CHAN] = (NEXTLO)*2 + 0001
i.e.
C[CHAN] replaced by address of new overflow channel shifted one place to the left and with the overflow indicator bit appended.
NEXTHI = NEXTHI + 0002
NEXTLO = NEXTLO + 0002
2143
RETURN (INCR)
INCRLO,2157
Clear the LINK
C[Addr.(ADDRLO)] = C[Addr.(ADDRLO)] + LINCR
2162
LINK
= 0
no overflow in the addition
2163
RETURN (INCR)
overflow in the addition
= 1
2164
C[Addr.(ADDRHI)] = C[Addr.(ADDRHI)] + 1
2166
RETURN (INCR)
PREVOV,2144
AC → ADDRLO
i.e.
address of low order part of {overflow / underflow} channel
ADDRHI = ADDRLO - 1
address of high order part
2150
LINCR
< 0
≥ 0
2153
Add 7777 to C[Addr.(ADDRHI)]

Fig. 14. Flow Diagram for INCR

ORNL DWG 67-6419

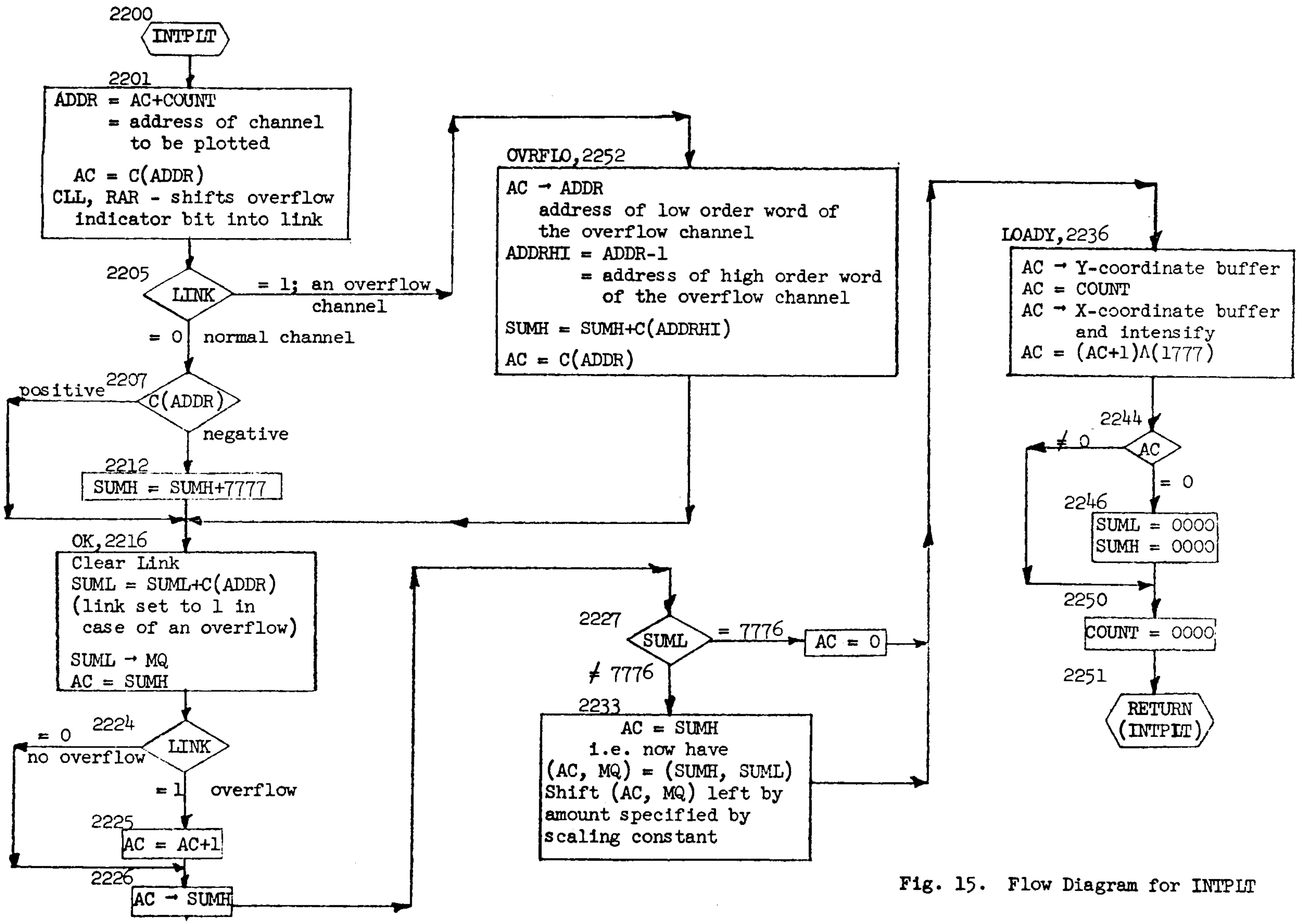


Fig. 15. Flow Diagram for INTPLT

ORNL DWG 67-6420

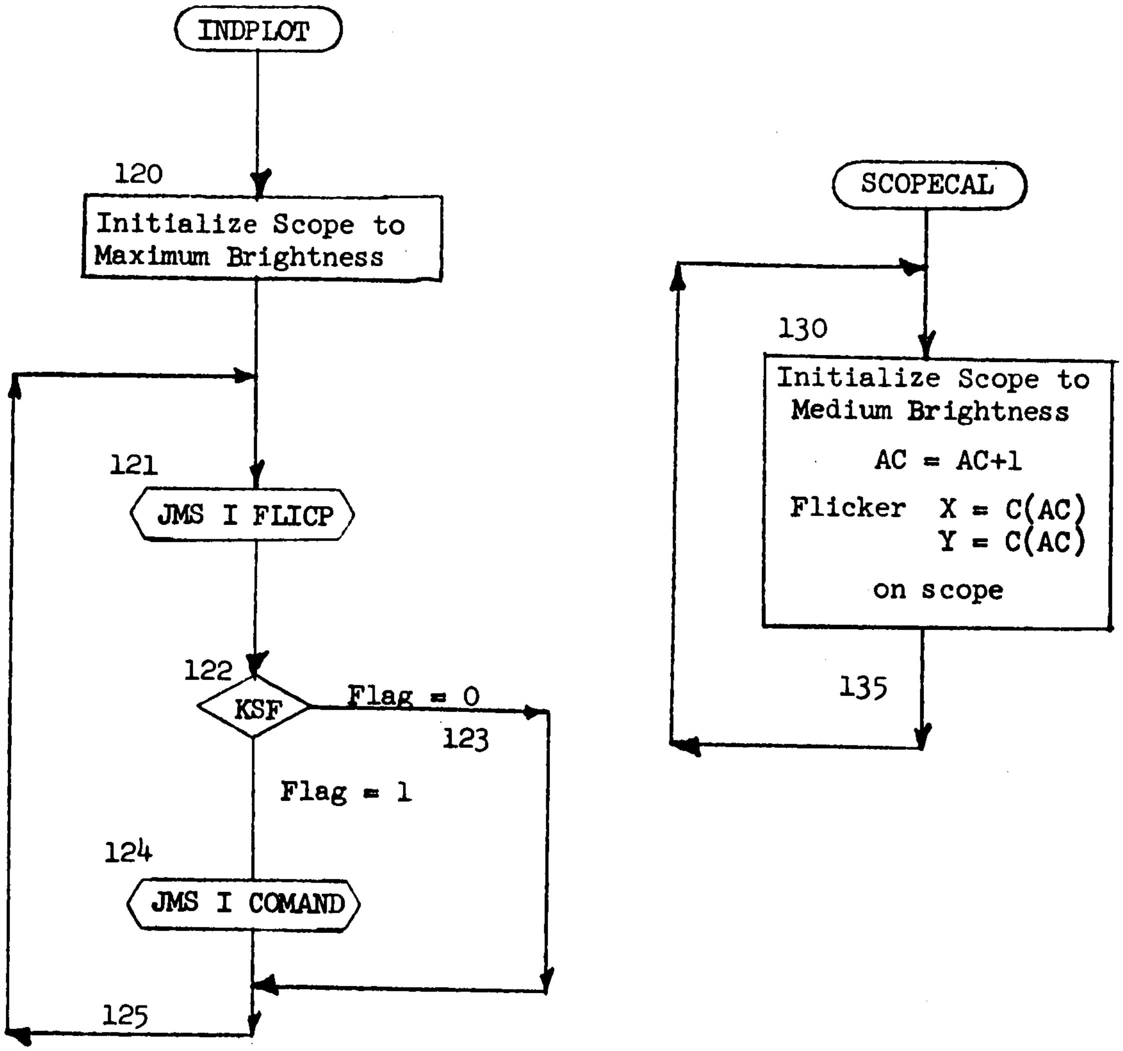


Fig. 16. Flow Diagram for INDPLOT and SCOPECAL

```
                / FLICKERS -- WRITES TAPE, FLICKERS, AND DERIVATIVE STØRAGE
                / PERMANENT SYMBØLS
                /
                *20
  20    1000    DBUFP,   1000     / 1ST LØC. ØF DATA BUFFER (400=8 WØRDS)
  21    3576    DSPECP,  3576     /1ST LØC. ØF B+C SPECTRUM FØR PARTICLES THAT STØP IN C.
  22    5577    ESPECP,  5577     /1ST LØC. ØF B+C+D SPECTRUM FØR PARTICLES STØPPING IN D.
  23    2576    TRBUFP,  2576     / 1ST LØC. ØF TAPE RECØRD BUFFER (1000=8 WØRDS)
  24     500    SAVED,   0500     /1ST LØC. ØF DATA TRANSFER RØUTINE
  25     600    REWP,     600     /1ST LØC. ØF REWIND RØUTINE
  26     602    RSKPP,    602     /1ST LØC. ØF RECØRD SKIPPING RØUTINE
  27     604    WRITEP,   604     /1ST LØC. ØF RECØRD WRITING RØUTINE
  30    2376    ØVRFLP,  2376     /1ST LØC. IN ØVERFLØW BUFFER
  31     606    READP,    606     /1ST LØC. ØF RECØRD READING RØUTINE
  32       0    DUMMY1,  0000
  33       0    DUMMY2,  0000
  34       0    NEXTHI,  0000     /ADDR. TØ BE HI-ØRDER WØRD ØF NEXT ØVERFLØW CHANNEL
  35       0    NEXTLØ,  0000     /ADDR. TØ BE LØ-ØRDER WØRD ØF NEXT ØVERFLØW CHANNEL
  36     550    BFCLRP,  0550     / 1ST LØC. IN BUFFER CLEARING RØUTINE
  37    1400    PLØTP,   1400     / 1ST LØC. IN PLØT PACKAGE
  40       0    DUMMY7,  0000
  41     400    ERRCKP,  0400     / 1ST LØC. ØF RØUTINE TØ CHECK FØR TAPE ERRØR
  42       0    BMARK,   0000     / INDEXING PARAMETER FØR DATA BUFFER
  43    2235    SCALEM,  2235     /SCALE FACTØR FØR INTEGRATING PLØT RØUTINE
  44      70    CØMAND,    70     /1ST LØC. ØF CØMMAND RØUTINE
  45    2000    SPECP,   2000     / 1ST LØC. IN SPECTRUM RØUTINE
  46    2200    INTPLT,  2200     /1ST LØC. IN INTEGRATING PLØT RØUTINE
  47       0    TNAT,       0     /LØC. FØR UNTRIMMED T-SIGNAL
  50     377    TMASK,   0377     /   MASK FØR TRIMMING T-SIGNAL
  51       0    TTR,        0     /      LØC. FØR TRIMMED T-SIGNAL
  52       0    BNAT,       0     /ETC.,
  53     377    BMASK,   0377     /      ETC.,
  54       0    BTR,        0     /           ETC. FØR B-SIGNAL
  55       0    CNAT,       0     /
  56    1777    CMASK,   1777     /
  57       0    CTR,        0     /            AND FØR C-SIGNAL
  60       0    DNAT,       0     /
  61    3777    DMASK,   3777     /
  62       0    DTR,        0     /            AND FØR D-SIGNAL

SYMBØL TABLE

BFCLRP      36
BMARK       42
BMASK       53
BNAT        52
BTR         54
CMASK       56
CNAT        55
CØMAND      44
CTR         57
DBUFP       20
DMASK       61
DNAT        60
DSPECP      21
DTR         62
DUMMY1      32
DUMMY2      33
DUMMY7      40
ERRCKP      41
```

```
ESPECP       22
INTFLT       46
NEXTHI       34
NEXTLØ       35
ØVRFLP       30
PLØTP        37
READP        31
REWP         25
RSKPP        26
SAVED        24
SCALEØ       43
SPLCP        45
TMASK        50
TNAT         47
TRBUFP       23
TTR          51
WRITEP       27

DUPLICATE TAGS

NØNE

UNDEFINED SYMBOLS

NØNE
```

```
                    / CØMMAND RØUTINE FØR SCALE CHANGING
                    /
                    *70
                    /
                    SCALEØ=43
                    /
    70     0   CØMAND, 0000
    71  6036           KRB                   /READ SCALE CØNSTANT FRØM KEYBØARD
    72  7041           CIA
    73  1076           TAD     P276
    74  3443           DCA   I SCALEØ  /  DEPØSIT IN SCALE CØNST. LØC.
    75  5470           JMP   I CØMAND
    76   276   P276,    276

SYMBØL TABLE

CØMAND       70
P276         76
SCALEØ       43

DUPLICATE TAGS

NØNE

UNDEFINED SYMBØLS

NØNE
```

```
                /INDPLØT
                /
                /THIS PRØGRAM ALLØWS INDEPENDENT PLØTTING WITH SCALE CHANGE
                FLICP=37
                CØMAND=44
                *120
 120  6077           DSB+3
 121  4437           JMS  I  FLICP
 122  6031          KSF
 123  5125          JMP      .+2
 124  4444          JMS I CØMAND
 125  5121          JMP      .-4
SYMBOL TABLE

CØMAND      44
FLICP       37

DUPLICATE TAGS

NØNE

UNDEFINED SYMBØLS

NØNE
```

```
                  /SCOPECAL
                  /
                  /STRAIGHT LINE SCOPE CALIBRATION PROGRAM
                  /SET DIAGONAL LINE TO RUN FROM (1,1) TO (10,8) ON SCOPE GRATICULE
                  /FOR FLICKERS PICTURES
                  *130
 130  6076              DSB+2
 131  7001              IAC
 132  6053              DXL
 133  6063              DYL
 134  6054              DIX
 135  5130              JMP       .-5

SYMBOL TABLE

DUPLICATE TAGS
NONE

UNDEFINED SYMBOLS
NONE
```

```
                  *140
                  /BBIAS ROUTINE FOR ELIMINATING TAPE FOR T-O-F EVENTS UNDER FIXED BIAS
                  B=52
                  C=55
                  BTRIM=54
 140     0        BBIAS, 0
 141  1055               TAD     C               /PICK UP C FOR FLAG 2
 142  7004               RAL
 143  7710                SPA CLA          /TEST FLAG 2
 144  5154               JMP     OK
 145  1052               TAD     B               /PICK UP B FOR FLAG 1
 146  7004               RAL
 147  7710                SPA CLA          /TEST FLAG1
 150  5154               JMP     OK
 151  1054               TAD     BTRIM
 152  1156               TAD     MBIAS           /MINUS BIAS IN CHANNELS
 153  7730               SMA CLA
 154  2140  OK,          ISZ     BBIAS
 155  5540               JMP  I  BBIAS
 156     0  MBIAS, 0                            /SET TO ZERO FOR NO BIAS, -14(8) FOR 600 KEV

SYMBOL TABLE

B            52
BBIAS       140
BTRIM        54
C            55
MBIAS       156
OK          154

DUPLICATE TAGS

NONE

UNDEFINED SYMBOLS

NONE
```

```
                 /FLICKERS
                 /
                 / SUPER DUPER DATA ACQUIZITION PRØGRAM WITH PØPPING TAPES
                 /
                 DBUFF=20
                 DSPECP=21
                 ESPECP=22
                 TRBUFP=23
                 SAVED=24
                 WRITEP=27
                 TNAT=47
                 BFCLRP=36
                 FLICP=37
                 ERRCKP=41
                 BMARK=42
                 SPECP=45
                 CØMAND=44
                 ANIFRZ=1736
                 ØVRFLP=32
                 NEXTHI=34
                 NEXTLØ=35
                 BBIAS=140
                 /
                 / INITIALIZATION PATCH
                 /
                 *0170
                 /
 170       0     INIT,    0000
 171    6032              KCC
 172    6046              TLS
 173    6041              TSF
 174    5173              JMP      .-1
 175    6077              DSB+3
 176    5570              JMP   I  INIT
                 /
                 *200
                 /
 200    7402     BEGIN,   HLT      /STØP FØR CØDE WORD TØ BE KEYED IN
 201    7200              CLA
 202    1023              TAD      TRBUFP
 203    3354              DCA      ADDR2
 204    1357              TAD      M0400
 205    3353              DCA      CØUNT
 206    7604     LP,      LAS
 207    3754              DCA   I  ADDR2
 210    2354              ISZ      ADDR2
 211    2353              ISZ      CØUNT
 212    5206              JMP      LP
 213    1023              TAD      TRBUFP
 214    3216              DCA      .+2
 215    4427              JMS   I  WRITEP   /WRITE THE IDENT. REC.
 216    7000              NØP
 217    1000              1000
 220    7402              HLT
 221    7200     CØNT,    CLA
 222    1021              TAD      DSPECP
 223    3225              DCA      .+2
 224    4436              JMS   I  BFCLRP   /CLEAR THE TWØ SPECTRUM BUFFERS
 225    7000              NØP
```

```
226  4002          4002
227  1050          TAD       OVRFLP
230  3054          DCA       NEXTHI  /INITIALIZE ØVERFLØW CHANNEL MARKERS
231  1054          TAD       NEXTHI
232  7001          IAC
233  3055          DCA       NEXTLØ
234  7402          HLT               /HIT CØNTINUE TØ TAKE DATA
235  4170  RESTRT, JMS       INIT
236  7200          CLA
237  1020          TAD       DBUFP   /INITIALIZE DATA BUFFER TØ ALL 0000
240  3242          DCA       .+2
241  4436          JMS   I   BFCLRP  /AC LEFT CLEARED BY BFCLRP
242  7000          ØPR
243   400          0400
244  3042          DCA       BMARK   /INITIALIZE BMARK TØ STEP THRU DATA BUFFER
245  6311          BADCLR            /CLEAR HARDWARE
246  6324          UDCLR
247  5334          JMP       TBFCLR
250  6312  LØØP,   BABLE     /START TAKING DATA
251  7200          CLA
252  1020          TAD       DBUFP
253  1042          TAD       BMARK
254  3364          DCA       BUFFAD
255  1764          TAD   I   BUFFAD  /EXAMINE CØNTENTS ØF LØC. BMARK ØF DATA BUFFER
256  5657          JMP   I   .+1     / JUMP TØ THE ANTIFREEZE PATCH
257  1736          ANTFRZ
260  7240  DATA,   CLA CMA           /USE AUTØ-INDEX REGISTER 10,11,12 TØ TRANSFER
261  1364          TAD       BUFFAD  /   THE DATA FØR THE EVENT TØ THE TAPE RECØRD
262  3010          DCA       10      /   BUFFER AND THE T,B,C,D WØRDS ØN PAGE ZERØ
263  7240          CLA CMA           /   WHICH ARE USED TØ TRANSMIT THE DATA TØ THE
264  1023          TAD       TRBUFP  /   SPECTRUM ACCUMULATING RØUTINE.
265  1365          TAD       EMARK
266  3011          DCA       11
267  1366          TAD       LISTP
270  3012          DCA       12
271  4424          JMS I     SAVED   /TRANSFER T-SIGNAL
272  4424          JMS I     SAVED   /         B-SIGNAL
273  4424          JMS I     SAVED   /         C-SIGNAL
274  4424          JMS I     SAVED   /         D-SIGNAL
275  4445          JMS   I   SPECP
276  4437          JMS   !   FLICP
277  7200          CLA
300  3764          DCA   I   BUFFAD
301  1042          TAD       BMARK
302  1356          TAD       L0004
303   363          AND       MASK2
304  3042          DCA       BMARK
305  6314          BDISAB
306  6333          UDSUB2
307  6333          UDSUB2
310  4140          JMS       BBIAS          /FØR BBIAS TEST TØ CØNSERVE TAPE FØR T-Ø-F
311  5250          JMP       LØØP           /BBIAS SKIPS THIS IF BIAS IS ØK
                                           /**CHANGE TAD EMARK TØ JMP LØØP FØR NØ TAPE
312  1365          TAD       EMARK
313  1356          TAD       L0004
314  3365          DCA       EMARK
315  2353          ISZ       CØUNT   /SKIP WHEN TAPE BUFFER IS FULL
316  5250          JMP       LØØP
317  7200  WRITE,  CLA               /IF TAPE BUFFER FULL WRITE A REC. ØN TAPE
320  1023          TAD       TRBUFP
```

```
321  3323          DCA      .+2
322  4427          JMS   I  WRITEP
323  7000          CPR
324  1000          1000
325  7201          CLA IAC           /CHECK EVERY 8TH RECØRD FØR AN ERRØR
326  1355          TAD      CKCNT
327   362          AND      MASK1
330  3355          DCA      CKCNT
331  1355          TAD      CKCNT
332  7450          SNA
333  4441          JMS   I  ERRCKP
334  7200  TBFCLR, CLA               /CLEAR TAPE BUFFER AND INITIALIZE EMARK AND COUNT
335  1023          TAD      TRBUFP   /     TO STEP THRU IT
336  3340          DCA      .+2
337  4436          JMS   I  BFCLRP   /AC LEFT CLEARED
340  7000          CPR
341  1000          1000
342  3365          DCA      EMARK
343  1361          TAD      M0200
344  3353          DCA      CØUNT
345  4437  PLØT,   JMS   I  FLICP
346  6031          KSF               /SKIP IF NEW SCALE CØNST, HAS BEEN TYPED IN
347  5351          JMP      .+2
350  4444          JMS   I  CØMAND
351  5250          JMP      LØØP
352     0  ADDR,   0000
353     0  CØUNT,  0000
354     0  ADDR2,  0000
355     0  CKCNT,  0000
356     4  L0004,  0004
357  7400  M0400,  7400
360     2  L0002,  0002
361  7600  M0200,  7600
362     7  MASK1,  0007
363   377  MASK2,  0377
364     0  BUFFAD, 0000
365     0  EMARK,  0000
366    46  LISTP,  TNAT-1
           /
           /
           *372
           /
372  5221          JMP      CØNT
373  5317  FLUSH,  JMP      WRITE
374  5250          JMP      LØØP
375  5260          JMP      DATA
376  5345          JMP      PLØT
377  5235          JMP      RESTRT
           /

SYMBØL TABLE

ADDR       352
ADDR2      354
ANTFRZ    1736
BBIAS      140
BEGIN      200
BFCLRP      36
BMARK       42
BUFFAD     364
CKCNT      355
```

```
CØMAND      44
CØNT       221
CØUNT      353
DATA       260
DBUFP       20
DSPECP      21
EMARK      365
ERRCKP      41
ESPECP      22
FLICP       37
FLUSH      373
INIT       170
L0002      360
L0004      356
LISTP      366
LØØP       250
LP         206
M0200      361
M0400      357
MASK1      362
MASK2      363
NEXTHI      34
NEXTLØ      35
ØVRFLP      30
PLØT       345
RESTRT     235
SAVED       24
SPECP       45
TBFCLR     334
TNAT        47
TRBUFP      23
WRITE      317
WRITEP      27

DUPLICATE TAGS

NØNE

UNDEFINED SYMBØLS

NØNE
```

```
                /ERRCK -- A RØUTINE TØ CHECK FØR TAPE ERRØRS
                /
                *0400
                /
                RSKPP=26
                READP=31
                TRBUFP=23
 400      0     ERRCK,  0
 401   4264             JMS     READY
 402   1256             TAD     L0510   /BACKSPACE ØVER ØNE RECØRD
 403   6707             TIFM
 404   6732             TCPI
 405   5204             JMP     .-1
 406   6724             TSST
 407   4264             JMS     READY
 410   1023             TAD     TRBUFP
 411   3257             DCA     RDADD
 412   1260             TAD     L1000
 413   7040             CMA
 414   3261             DCA     RDCNT
 415   1262             TAD     L2570   /CØDE FØR READING
 416   6707             TIFM
 417   6721             TSDF
 420   5217             JMP     .-1
 421   5226             JMP     RDWØRD
 422   6722     RDLØØP, TSSR
 423   5222             JMP     .-1
 424   6721             TSDF
 425   5241             JMP     ENDREC
 426   6715     RDWØRD, TSRD
 427   2261             ISZ     RDCNT
 430   5232             JMP     .+2
 431   5250             JMP     ERRØR   /SIZE ERRØR
 432   7041             CIA
 433   1657             TAD   I RDADD   /CØMPARE WØRD READ FRØM TAPE WITH CØRRESPØNDING
 434   7440             SZA             /     WØRD IN CØRE
 435   5250             JMP     ERRØR   / IF THE TWØ WØRDS DØ NØT AGREE
 436   2257             ISZ     RDADD
 437   5222             JMP     RDLØØP
 440   5250             JMP     ERRØR   /INITIAL ADDRESS ERRØR
 441   6734     ENDREC, TSRS
 442   7500             SMA
 443   5245             JMP     SZCHK
 444   5250             JMP     ERRØR   /PARITY ERRØR
 445   2261     SZCHK,  ISZ     RDCNT
 446   5250             JMP     ERRØR   /SIZE ERRØR
 447   5600             JMP   I ERRCK
 450   7200     ERRØR,  CLA
 451   1263             TAD     L0305
 452   6041             TSF
 453   5252             JMP     .-1
 454   6046             TLS
 455   5600             JMP   I ERRCK
                /
 456    510     L0510,  0510
 457      0     RDADD,  0
 460   1000     L1000,  1000
 461      0     RDCNT,  0
 462   2570     L2570,  2570
 463   305  L0305,  0305     /ASCII CODE FØR E
 464     0  READY,  0
 465  7200          CLA
 466  6734          TSRS
 467  7006          RTL
 470  7700          SMA CLA
 471  5266          JMP      .-3
 472  5664          JMP  I   READY
SYMBOL TABLE
ENDREC      441
ERRCK       400
ERRØR       450
L0305       463
L0510       456
L1000       460
L2570       462
RDADD       457
RDCNT       461
RDLØØP      422
RDWØRD      426
READP        31
READY       464
RSKPP        26
SZCHK       445
TRBUFP       23
DUPLICATE TAGS
NØNE
UNDEFINED SYMBOLS
NØNE
```

```
                / SAVED -- A SUBRØUTINE WHICH USES THE AUTØ-INDEX REGISTERS 10,11,12 TØ
                /           TRANSFER THE DATA FØR AN EVENT FRØM DATA BUFFER TØ TAPE
                /           RECØRD BUFFER AND TØ FØUR WØRDS ØN PAGE ZERØ (47,52,55,60)
                /           USED BY THE SPECTRUM ACCUMULATING RØUTINE.
                /           THE PRØGRAM ALSØ TRIMS THE WØRDS (47,52,55,60) WITH THE
                /           MASKS IN (50,53,56,61) AND STØRES THE TRIMMED WØRDS IN
                /           LØCATIØNS (51,54,57,62)
                /
                *500
 500      0     SAVED,  0000
 501   1410             TAD  I  10      /GET THE SIGNAL
 502   3313             DCA     TEMP
 503   1313             TAD     TEMP
 504   3411             DCA  I  11      /  STØRE IT IN TAPE RECØRD BUFFER
 505   1313             TAD     TEMP
 506   3412             DCA  I  12      /  STØRE IT ØN PAGE ZERØ
 507   1313             TAD     TEMP
 510    412             AND  I  12      /  MASK THE SIGNAL
 511   3412             DCA  I  12      /   AND STØRE TRIMMED RESULT ØN PAGE ZERØ ALSØ
 512   5700             JMP  I  SAVED
                /
 513      0     TEMP,   0000
                /

SYMBØL TABLE

SAVED      500
TEMP       513

DUPLICATE TAGS

NØNE

UNDEFINED SYMBØLS

NØNE
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```
               / BFCLR -- A RØUTINE FØR CLEARING BUFFERS
               /
               / CALLING SEQUENCE       JMS I BFCLRP
               /                        XXXX          /1ST LØC IN BUFFER
               /                        XXXX          /NØ. WØRDS IN BUFFER
               /                       (CØNTINUE)
               /
               *550
               /
 550      0    BFCLR,   0000
 551   7200             CLA
 552   1750             TAD  I  BFCLR
 553   3366             DCA     ADDR
 554   2350             ISZ     BFCLR
 555   1750             TAD  I  BFCLR
 556   7041             CIA
 557   3367             DCA     CØUNT
 560   2350             ISZ     BFCLR   /RETURN ADDRESS NØW IN BFCLR
 561   3766    LØØP,    DCA  I  ADDR
 562   2366             ISZ     ADDR
 563   2367             ISZ     CØUNT
 564   5361             JMP     LØØP
 565   5750             JMP  I  BFCLR
 566      0    ADDR,    0000
 567      0    CØUNT,   0000
               /
               / NØTE -- THE AC IS LEFT CLEARED
               /

 SYMBØL TABLE

 ADDR       566
 BFCLR      550
 CØUNT      567
 LØØP       561

 DUPLICATE TAGS

 NØNE

 UNDEFINED SYMBØLS

 NØNE
```

```
                  /SYSPOP -- A SYSTEM OF SUBROUTINES FOR POPPING THE TAPE
                  /
                  /         ALL ENTRIES GIVEN FIRST WITH JUMPS TO CORRESPONDING SUBROUTINES
                  /
                  /         THE CALLING SEQUENCE FOR EACH ENTRY IS DESCRIBED JUST BEFORE
                  /         SUBROUTINE CORRESPONDING TO THAT ENTRY.
                  /
                  *600
                  /
 600     0        REWIND, 0000                /ENTRY FOR TAPE REWIND
 601  5210                JMP      BGNREW
 602     0        RECSKP, 0000                /ENTRY FOR SKIPPING RECORDS
 603  5216                JMP      BGNSKP
 604     0        WRITE,  0000                /ENTRY FOR WRITING A RECORD
 605  5240                JMP      BGNWRT
 606     0        READ,   0000                /ENTRY FOR READING A RECORD
 607  5277                JMP      BGNRD
                  /
                  /
                  /
                  /REWIND -- A ROUTINE FOR REWINDING THE TAPE
                  /
                  /    CALLING SEQUENCE       JMS I REWP /REWP CONTAINS ADDR. OF REWIND ENTRY
                  /                           (CONTINUE) /CONTROL RETURNED HERE
                  /
 610  4352        BGNREW, JMS      READY      /WAIT UNTIL UNIT IS READY
 611  1215                TAD      L0002      /LOAD COMMAND CODE FOR REWIND
 612  6707                TIFM                /  AND START TAPE MOVING
 613  4352                JMS      READY      /WAIT UNTIL REWIND COMPLETED
 614  5600                JMP  I   REWIND     /  AND THEN RETURN
 615     2        L0002,  0002
                  /
                  /
                  /
                  /RECSKP -- A ROUTINE FOR SKIPPING RECORDS ON TAPE
                  /
                  /  CALLING SEQUENCE         CLL (STL)    /FOR SKIPPING FORWARD (BACKWARD)
                  /                           JMS I RSKPP  /RSKPP CONTAINS ADDR. OF RECSKP ENTRY
                  /                           XXXX         /NO. OF RECORDS TO SKIP
                  /                           (CONTINUE)   /CONTROL RETURNED HERE
                  /
 616  4352        BGNSKP, JMS      READY      /WAIT UNTIL TAPE UNIT READY
 617  1602                TAD  I   RECSKP
 620  7041                CIA                 / NEG. OF NO. RECS. TO SKIP
 621  3235                DCA      RCCNT
 622  2202                ISZ      RECSKP     /  RECSKP NOW CONTAINS RETURN ADDRESS
                  /
 623  1236                TAD      L0530      /LOAD COMMAND CODE FOR SKIPPING
 624  7430                SZL
 625  1237                TAD      M0020      /        FOR SKIPPING BACKWARDS
 626  6707                TIFM                /  AND START TAPE MOVING
 627  6732        SKLOOP, TCPI                /SKIP AFTER EACH RECORD
 630  5227                JMP      .-1
 631  2235                ISZ      RCCNT      / SKIP AFTER LAST REC.
 632  5227                JMP      SKLOOP
 633  6724                TSST                /STOP TAPE MOTION
 634  5602                JMP  I   RECSKP
 635     0        RCCNT,  0000
 636   530        L0530,  0530
```

```
637  7760  M0020,  7760
                /
                /
                /
                / WRITE -- A ROUTINE FOR WRITING A BLOCK OF STORAGE AS A RECORD ON TAPE
                /
                /   CALLING SEQUENCE     JMS I WRITEP /WRITEP CONTAINS LOC OF WRITE ENTRY
                /                        XXXX         /ADDR. OF 1ST LOC. OF BLOCK TO WRITE
                /                        XXXX         /NO. OF WORDS TO WRITE
                /                        (CONTINUE)   /CONTROL RETURNED HERE
                /
640  4352  BGNWRT, JMS      READY
641  1604          TAD   I  WRITE
642  3274          DCA      WRADD    /ADDR. OF 1ST LOC IN BLOCK
643  2204          ISZ      WRITE
644  1604          TAD   I  WRITE
645  7041          CIA               /NEG. OF NO. WORDS
646  3275          DCA      WRCNT
647  2204          ISZ      WRITE    /RETURN ADDR. LEFT IN WRITE
                /
650  1273          TAD      L2730    /LOAD COMMAND CODE FOR WRITING
651  6707          TIFM              /  AND START TAPE MOVING
652  7200  WRLOOP, CLA
653  1674          TAD   I  WRADD    /PICK UP A WORD
654  6716          TSWR              /  AND WRITE IT
655  6721          TSDF              / SKIP WHEN READY FOR NEXT WORD
656  5255          JMP      .-1
657  2274          ISZ      WRADD    / COMPUTE ADDR. OF NEXT WORD
660  2275          ISZ      WRCNT    / SKIP IF LAST WORD HAS BEEN WRITTEN
661  5252          JMP      WRLOOP
662  6724          TSST              /STOP THE TAPE
                /
                /   AFTER WRITING THE RECORD THE PROGRAM CHECKS FOR THE END OF TAPE
                /      IF THE E. O. T. HAS BEEN ENCOUNTERED, PROG. STOPS WITH 4444 IN AC
                /
663  7200          CLA
664  6734          TSRS              /TAPE STATUS REGISTER INTO AC(0-5)
665  7006          RTL               /END OF TAPE
666  7006          RTL               /      BIT INTO AC(0)
667  7700          SMA CLA           /SKIP IF END OF TAPE
670  5604          JMP   I  WRITE    /  OTHERWISE RETURN
671  1276          TAD      L4444
672  7402          HLT
673  2730  L2730,  2730
674     0  WRADD,  0000
675     0  WRCNT,  0000
676  4444  L4444,  4444
                /
                /
                /
                /
                / READ -- A ROUTINE FOR READING A RECORD FROM TAPE INTO A BLOCK OF STORAGE
                /
                /  CALLING SEQUENCE      JMS  I  READP    /READP CONTAINS ADDR. OF READ ENTRY
                /                        XXXX             /ADDR OF 1ST LOC TO READ INTO
                /                        XXXX             /NO. OF WORDS IN RECORD
                /                        (CONTINUE)       /CONTROL RETURNED HERE
                /
                /  ERROR STOPS    1111 IN AC MEANS INITIAL ADDR. TOO HIGH FOR RECORD TO
                /                                FIT WITHOUT OVERFLOWING THE TOP OF CORE.
                /                                   THE RIM LØADER WAS PRØBABLY DESTRØYED
                /                       2222 IN AC MEANS PARITY ERRØR
                /                       7777 IN AC MEANS SIZE ERRØR
                /
677   4352   BGNRD,  JMS      READY
700   1606           TAD  I   READ
701   3350           DCA      RDADD   /ADDR ØF 1ST LØC. TØ READ INTØ
702   2206           ISZ      READ
703   1606           TAD  I   READ
704   7040           CMA
705   3351           DCA      RDCNT   /CØMP. ØF NØ. WØRDS IN RECØRD
706   2206           ISZ      READ    /RETURN ADDR. NØW IN READ
                /
707   1345           TAD      L2570   /LØAD CØMMAND CØDE FØR READING
710   6707           TIFM             /  AND START TAPE MØVING.
711   6721           TSDF             /SKIP WHEN READY TØ READ FIRST WØRD
712   5311           JMP      .-1
713   5320           JMP      RDWØRD
                /
714   6722   RDLØØP, TSSR             /SKIP ØN NEW WØRD ØR END ØF RECØRD
715   5314           JMP      .-1
716   6721           TSDF             /  SKIP IF IT IS NEW WØRD
717   5332           JMP      ENDREC
720   6715   RDWØRD, TSRD             /READ A WØRD
721   2351           ISZ      RDCNT   /   SKIP IF NØ MØRE WØRDS WERE EXPECTED
722   5324           JMP      .+2     /      (IE. REC. ØN TAPE IS TØØ BIG)
723   5343           JMP      SZERR
724   3750           DCA  I   RDADD   /   ØTHERWISE STØRE THE WØRD
725   2350           ISZ      RDADD   /      AND CØMPUTE ADDR. FØR NEXT ØNE
726   5314           JMP      RDLØØP
727   6701           TIFM-6           /EMERGENCY STØP (IØT+0701) -- IF CØNTRØL
730   1346           TAD      L1111   /   REACHES THIS PØINT THE RECØRD HAS
731   7402           HLT              /   ØVERFLØWED THRØUGH TØP ØF CØRE
                /
732   6734   ENDREC, TSRS             /END ØF RECØRD HAS BEEN DETECTED.
733   7500           SMA              / SKIP ØN PARITY ERRØR
734   5340           JMP      SZCHK   /   ØTHERWISE CHECK FØR SIZE ERRØR
735   7200           CLA
736   1347           TAD      L2222
737   7402           HLT
740   2351   SZCHK,  ISZ      RDCNT   /IF NØ SKIP HERE THEN PRØGRAM EXPECTS MØRE WØRDS
741   5343           JMP      SZERR   /     (IE. THE RECØRD ØN TAPE WAS TØØ SHØRT)
742   5606           JMP  I   READ
743   7240   SZERR,  CLA CMA
744   7402           HLT
745   2570   L2570,  2570    /CØMMAND CØDE FØR READING
746   1111   L1111,  1111
747   2222   L2222,  2222
750      0   RDADD,  0000
751      0   RDCNT,  0000
                /
                /
                /READY -- A RØUTINE TØ WAIT UNTIL TAPE UNIT IS READY
                /
                /   THE AC IS CLEARED BEFØRE RETURNING TØ CALLING RØUTINE
                /
752      0   READY,  0000
753   7200   BEGIN,  CLA
754   6734   LØØP,   TSRS                     /TAPE STATUS REGISTER INTØ AC(0-5)
755   7006           RTL                      /  TRANSPØRT IS READY BIT INTØ AC(0)
```

```
 756  7700            SMA CLA           /SKIP IF TRANSPØRT IS READY
 757  5354            JMP      LØØP
 760  5752            JMP   I  READY
                /

SYMBØL TABLE

BEGIN      753
BGNRD      677
BGNREW     610
BGNSKP     616
BGNWRT     640
ENDREC     732
L0002      615
L0530      636
L1111      746
L2222      747
L2570      745
L2730      673
L4444      676
LØØP       754
M0020      637
RCCNT      635
RDADD      750
RDCNT      751
RDLØØP     714
RDWØRD     720
READ       606
READY      752
RECSKP     602
REWIND     600
SKLØØP     627
SZCHK      740
SZERR      743
WRADD      674
WRCNT      675
WRITE      604
WRLØØP     652

DUPLICATE TAGS

NØNE

UNDEFINED SYMBØLS

NØNE
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```
            /FLIC -- A FLICKER BOX AND PLOTTING PROGRAM
            /
            /  ASSUMES ALERTS ARE .NOT.A B OR .NOT.A B C
            /                                                                  /
            /   THIS PROGRAM IS CALLED ONLY ONCE PER EVENT IN OPTIONS 3 OR ABOVE,  /
            /   BUT AS OFTEN AS POSSIBLE IN ALL OTHER OPTIONS.                    /
            /
            /   OPTION 0  DOES NOTHING (RETURNS)
            /          1  DISPLAY B+C WITH 2000(8) F.S.
            /          2  DISPLAY B+C+D WITH 2000(8) F.S,
            /   OPTION 3    FLICKERS 2C VS. (C+D)/2 WITH 2000(8) DOTS FULL SCALE
            /               THROW OUT WITHOUT FLICKERING IF ANY OVERFLOW FLAGS ON OR
            /               IF FLAG2 = 0 OR IF 2C .EG. 1024 OR IF (C+D)/2 .EG. 1024
            /               OR IF FLAG4=1  (PILE-UP FLAG IS ON)
            /          4  FLICKER 2B VS. (B+C) WITH 2000(8) DOTS F.S.
            /             THROW OUT IF ANY OVERFLOWS
            /                       IF BC = 0
            /                       IF BCD = 1
            /                       IF 2B .GE. 2000(8)
            /                       IF (B+C) .GE. 2000(8)
            /               ALSO THROW THE EVENT OUT IF FLAG4 = 1  (PILE UP FLAG ON)
            /
            /
            /                    NOTE   OPTIONS 5 AND ABOVE ARE ON THE
            /                             PAGE BEGINNING AT LOC. 1600.
            /
            /
            /          5  FLICKER 2(B+C) VS. (B+C+D)/2
            /             THROW OUT IF ANY OVERFLOWS
            /                       IF BCD = 0
            /                       IF 2(B+C) .EG 2000
            /                       IF (B+C+D)/2 .EG. 2000
            /               ALSO THROW THE EVENT OUT IF FLAG4 = 1  (PILE UP FLAG ON)
            /          6  FRED BERTRAND TIME-OF-FLIGHT OPTION
            /          7  DRAWS A BOX AROUND THE DISPLAY AREA FOR SCOPE CALIBRATION
            /
            /
            /
            DBUFP=20
            BMARKP=42
            FLAG2S=L2000
            DSPEC=21
            ESPEC=22
            INTPLT=46
            T=47
            TTR=51
            B=52
            BTR=54
            C=55
            CTR=57
            D=60
            DTR=62
            RETURN=5600
            *1400
1400     0  FLIC,    0
1401  7604           LAS
1402   347           AND     L0007
1403  1346           TAD     L5206   /5206 IS RUST NONRELOCATABLE OCTAL FOR JMP .+3
1404  3205           DCA     .+1
```

```
1405      0            00              /JMP 606,607,...,615
1406   5600            JMP   I  FLIC   /0  (RETURN)
1407   5221            JMP      ØP1    /1
1410   5225            JMP      ØP2    /2
1411   5231            JMP      ØP3    /3
1412   5307            JMP      ØP4    /4
1413   4616            JMS   I  ØP5P
1414   4617            JMS   I  ØP6P
1415   4620            JMS   I  ØP7P
              /
1416   1600   ØP5P,    1600            /ØPTIØNS 5 AND ABØVE ARE TØ BE FØUND
1417   1602   ØP6P,    1602            /  ØN THE PAGE BEGINNING WITH
1420   1604   ØP7P,    1604            /    LØCATIØN 1600
              /
1421   7200   ØP1,     CLA             /GØ TØ INTEGRATING
1422   1021            TAD      DSPEC  /PLØT FØR DELTA E PLØT
1423   4446            JMS   I  INTPLT
1424   5600            JMP   I  FLIC
              /
1425   7200   ØP2,     CLA             /GØ TØ INTEGRATING
1426   1022            TAD      ESPEC  /PLØT FØR TØTAL ENERGY
1427   4446            JMS   I  INTPLT /PLØT
1430   5600            JMP   I  FLIC
              /
1431   7200   ØP3,     CLA             / *** 2C VS. (C+D)/2
1432   1020            TAD      DBUFP
1433   1042            TAD      BMARKP
1434   3302            DCA      TEMP1
1435   1702            TAD   I  TEMP1  /PICK UP THE A-SIGNAL
1436    306            AND      L1000  /SIEVE FLAG4 ØNLY
1437   7510            SPA
1440   5600            JMP   I  FLIC   /IF FLAG4 IS ØN  (PILE UP)
1441   2302            ISZ      TEMP1  /IF FLAG4 NØT ØN (NØ PILE UP)
1442   1702            TAD   I  TEMP1  / PICK UP FLAG2
1443   7004            RAL
1444   7500            SMA
1445   5600            JMP   I  FLIC   / RETURN IF FLAG2 ØFF
1446   7200            CLA
1447   2302            ISZ      TEMP1
1450   1702            TAD   I  TEMP1  / PICKS UP C
1451    304            AND      L5000  /CHECK FØR ØVERFLØW ØR IF 2C .GE. 1024
1452   7440            SZA
1453   5600            JMP   I  FLIC   /RETURN IF ØVERFLØW ØR IF 2C .GE. 1024
1454   1702            TAD   I  TEMP1  / PICK UP C AGAIN
1455   7104            CLL RAL         / MULTIPLY BY 2
1456   6063            DYL
1457   7200            CLA
1460   1302            TAD      TEMP1
1461   7001            IAC
1462   3303            DCA      TEMP2
1463   1703            TAD   I  TEMP2  / PICK UP D
1464    305            AND      L4000
1465   7440            SZA
1466   5600            JMP   I  FLIC   / RETURN IF ØVERFLØW
1467   1702            TAD   I  TEMP1  / PICK UP C
1470   1703            TAD   I  TEMP2  / ADD D
1471   7110            CLL RAR         / DIVIDE SUM (C+D) BY 2
1472   3303            DCA      TEMP2
1473   1303            TAD      TEMP2
1474    344            AND      L6000  /CHECK IF (C+D)/2 .GE. 1024
```

```
1475  7440            SZA
1476  5600            JMP   I  FLIC     /RETURN IF (C+D)/2 .GE. 1024
1477  1303            TAD      TEMP2
1500  6057            DXS
1501  5600            JMP   I  FLIC
1502     0  TEMP1,    0000
1503     0  TEMP2,       0
1504  5000  L5000,    5000
1505  4000  L4000,    4000
1506  1000  L1000,    1000
            /
1507  1047  ØP4,      TAD T                     / *** 2B VS. (B+C)
1510   351            AND      SIEVE
1511  7440            SZA
1512  5600            RETURN            /PULSER ØR PILEUP ACCØRDING TØ SIEVE
1513  1052            TAD      B
1514  7510            SPA
1515  5600            RETURN            /B ØVERFLØ
1516  7104            CLL RAL
1517  7510            SPA
1520  5600            RETURN            /FLAG2 = 1
1521  7004            RAL
1522  7510            SPA
1523  5600            RETURN            /2B ØVERFLØ
1524  7010            RAR
1525  6063            DYL               /2B TØ Y AXIS
1526  7200            CLA
1527  1055            TAD      C
1530  7510            SPA
1531  5600            RETURN            /C ØVERFLØ
1532  7006            RTL
1533  7420            SNL
1534  5600            RETURN            /FLAG1 = 0
1535  7112            CLL   RTR         /TRIMS FLAG1
1536  1052            TAD      B
1537  6053            DXL               /(B+C) TØ X AXIS
1540   344            AND      L6000
1541  7450            SNA               /SKIP IF  (B+C) .GT. 1777
1542  6054            DIX
1543  5600            RETURN
            /
            / ØPTIØNS 5 AND ABØVE ARE ØN PAGE BEGINNING AT 1600
            /
1544  6000  L6000,    6000
1545  2000  L2000,    2000
1546  5206  L5206,    5206
1547     7  L0007,       7
1550     0  PØINT,       0
1551  1000  SIEVE,            1000
1552     0  TEMP,                0
1553  1777  L1777,             1777

SYMBØL TABLE

B           52
BMARKP      42
BTR         54
C           55
CTR         57
D           60
DBUFP       20
```

```
DSPEC         21
DTP           62
ESPEC         22
FLAG2S         0
FLIC        1400
INIPLT        45
L0007       1547
L1000       1506
L1777       1553
L2000       1545
L4000       1505
L5000       1504
L5206       1546
L6000       1544
ØP1         1421
ØP2         1425
ØP3         1431
ØP4         1507
ØP5P        1416
ØP6P        1417
ØP7P        1420
PØINT       1550
RETURN      5600
SIEVE       1551
T             47
TEMP        1552
TEMP1       1502
TEMP2       1503
TTR           51

DUPLICATE TAGS

NØNE

UNDEFINED SYMBOLS

NØNE
```

```
                    / ØPTIØNS 5,6,7 FØR FLIC
                    /
                    T=47
                    TTR=51
                    B=52
                    BTR=54
                    C=55
                    CTR=57
                    D=60
                    DTR=62
                    PLØTP=37
                    /
                    *1600
                    /
1600       0        ØP5,    0000
1601    5206                JMP     BGNØP5
1602       0        ØP6,    0000
1603    5254                JMP     BGNØP6
1604       0        ØP7,    0000
1605    5310                JMP     BGNØP7
                    /
                    /
1606    1047        BGNØP5, TAD     T        /*** 2(B+C) VS. (B+C+D)/2
1607     250                AND     SIEVE
1610    7640                SZA CLA
1611    5321                JMP     RETURN   /RETURN (PULSER ØR PILEUP ACCØRDING TØ SIEVE)
1612    1052                TAD     B
1613    7510                SPA
1614    5321                JMP     RETURN   /RETURN (B ØVERFLØ)
1615    7106                CLL RTL
1616    7420                SNL
1617    5321                JMP     RETURN   /RETURN (FLAG2 = 0)
1620    7112                CLL RTR          /TRIMS FLAG2
1621    3251                DCA     TEMP     /SAVE B
1622    1055                TAD     C
1623    7510                SPA
1624    5321                JMP     RETURN   /RETURN (C ØVERFLØ)
1625     252                AND       L1777 /C TRIMMED
1626    1251                TAD     TEMP
1627    7106                CLL RTL
1630    7510                SPA
1631    5321                JMP     RETURN   /RETURN (2(B+C) ØVERFLØ)
1632    7010                RAR
1633    6063                DYL              /2(B+C) TØ Y AXIS
1634    7010                RAR
1635    3251                DCA     TEMP     /SAVE (B+C)
1636    1060                TAD     D
1637    7510                SPA
1640    5321                JMP     RETURN   /RETURN (D ØVERFLØ)
1641    1251                TAD     TEMP
1642    7110                CLL RAR
1643    6053                DXL              /(B+C+D)/2 TØ X AXIS
1644     253                AND     L6000
1645    7450                SNA              /SKIP IF (B+C+D)  .GT. 1777
1646    6064                DIY
1647    5321                JMP     RETURN
                    /
1650    1000        SIEVE,  1000
1651       0        TEMP,   0000
```

```
 1652  1777  L1777,   1777
 1653  6000  L6000,   6000
             /
             /
 1654  7200  BGNOP6,  CLA                 /IF FLAG1 AND FLAG2 ARE 0 THEN FLICKER 4T VS. 2B
 1655  1052           TAD       B
 1656  7004           RAL
 1657  7510           SPA                 /TEST FLAG2  (BCD)
 1660  5321           JMP       RETURN
 1661  7200           CLA
 1662  1055           TAD       C
 1663  7004           RAL
 1664  7510           SPA                 /TEST FLAG1  (BCD)
 1665  5321           JMP       RETURN
 1666  7300           CLA CLL
 1667  1047           TAD       T         /PICK UP T
 1670  7510           SPA
 1671  5321           JMP       RETURN
 1672   305           AND       L0377
 1673  7006           RTL
 1674  6063           DYL
 1675  7300           CLA CLL
 1676  1052           TAD       B
 1677  7510           SPA
 1700  5321           JMP       RETURN
 1701   306           AND       L0777
 1702  7004           RAL
 1703  6057           DXS
 1704  5321           JMP       RETURN
 1705   377  L0377,   0377
 1706   777  L0777,   0777
 1707  5321           JMP       RETURN
 1710  7240  BGNOP7,  CLA CMA             /MAKES A ...BOX... FOR ADJUSTING SCOPE
 1711  6054           DIX                 /INTENSIFIES THE BOX.  ASSUMES LONG DSB
 1712  6053           DXL
 1713  6063           DYL
 1714  7200           CLA
 1715  6053           DXL
 1716  6063           DYL
 1717  5321           JMP       RETURN
 1720  5321           JMP       RETURN
             /
 1721  7200  RETURN,  CLA
 1722  1437           TAD  I    PLOTP
 1723  3325           DCA       RTNP
 1724  5725           JMP  I    RTNP
 1725     0  RTNP,    0000

SYMBOL TABLE

B          52
BGNOP5   1606
BGNOP6   1654
BGNOP7   1710
BTR        54
C          55
CTR        57
D          60
DTR        62
L0377    1705
L0777    1706
```

```
L1777       1652
L6000       1653
ØP5         1600
ØP6         1602
ØP7         1604
PLOTP         37
RETURN      1721
RTNP        1725
SIEVE       1650
T             47
TEMP        1651
TTR           51

DUPLICATE TAGS
NØNE

UNDEFINED SYMBØLS
NØNE
```

```
                / ANTIFREEZE SUBRØUTINE
                /
                *1736
                /
1736  7650   ANTFRZ, SNA CLA               /SKIP IF NEW DATA HAS ARRIVED
1737  5344           JMP      WAIT
1740  1360           TAD      M4
1741  3365           DCA      CØUNT
1742  3366           DCA      RØLLØ
1743  5762           JMP   I  DATAP
1744  2366   WAIT,   ISZ      RØLLØ
1745  5367           JMP      CHECK
1746  2365           ISZ      CØUNT
1747  5367           JMP      CHECK
1750  1360           TAD      M4
1751  3365           DCA      CØUNT
1752  3366           DCA      RØLLØ
1753  1361           TAD      BELL
1754  6041           TSF
1755  5354           JMP      .-1
1756  6046           TLS
1757  5764           JMP   I  RESTRP
             /
1760  7774   M4,         -4
1761   207   BELL,   0207
1762   375   DATAP,  0375
1763   376   PLØTP,  0376
1764   377   RESTRP, 0377
1765     0   CØUNT,  0
1766     0   RØLLØ,  0
             /
1767  7604   CHECK,  LAS               /FØR ØPT .GE. 3 GØ BACK THRU LØØP W/Ø PLØTTING
1770   377           AND      L0007
1771  1376           TAD      M0002    /  FØR ØPTIØNS 0,1,2 PLØT BEFØRE RETURNING TØ
1772  7550           SPA SNA           /  LØØP
1773  5763           JMP   I  PLØTP
1774  5775           JMP   I  LØØPP
1775   374   LØØPP,  0374
1776  7776   M0002,  7776
1777     7   L0007,  0007

SYMBØL TABLE

ANTFRZ      1736
BELL        1761
CHECK       1767
CØUNT       1765
DATAP       1762
L0007       1777
LØØPP       1775
M0002       1776
M4          1760
PLØTP       1763
RESTRP      1764
RØLLØ       1766
WAIT        1744

DUPLICATE TAGS

NØNE
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```
UNDEFINED SYMBOLS
NAME
```

```
            /SPEC-3D SPECTRUM ACCUMULATING ROUTINES
            /THIS VERSION STORES DERIVATIVES OF B+C AND B+C+D
            /    THE BUFFERS ARE 2001(8) WORDS LONG
            /    B+C BUFFER HAS 2 CHAN/WORD (INCREMENTED IF F1=1 AND F2=0,
            /                                        I.E. IF PARTICLE STOPPED IN C)
            /    B+C+D BUFFER HAS 2 CHAN/WORD (INCREMENTED IF F2=1, I.E. IF PARTICLE
            /                                          STOPPED IN D)
            /    THERE IS NO ACCUMULATION IF OVERFLOWS
            /
            *2000
            DSPEC=21        /DELTA E
            ESPEC=22        /TOTAL ENERGY
            NEXTHI=34
            NEXTLO=35
            T=47
            TTR=51
            B=52
            BTR=54
            C=55
            CTR=57
            D=60
            DTR=62
            RETURN=5600
2000     0  SPEC,   00
2001  1047          TAD     T
2002   274          AND     STEVE
2003  7640          SZA CLA
2004  5600          RETURN          /PULSER OR PILEUP
2005  1052          TAD     B
2006  7510          SPA
2007  5600          RETURN          /B OVERFLO
2010  7104          CLL RAL
2011  7710          SPA CLA
2012  5235          JMP     F2ONE
2013  1055  F2ZERO, TAD     C
2014  7004          RAL
2015  7710          SPA CLA
2016  5224          JMP     .+6
2017  1047          TAD     T
2020  7004          RAL
2021  7700          SMA CLA
2022  5600          RETURN
2023  5235          JMP     F2ONE
2024  1055          TAD     C       /*****INCREMENT B+C
2025  7510          SPA
2026  5600          RETURN          /C OVERFLO
2027   276          AND     L1777
2030  1052          TAD     B
2031  7110          CLL RAR
2032  1021          TAD     DSPEC
2033  4264          JMS     ADD1
2034  5600          RETURN
2035  1055  F2ONE,  TAD     C       /*****INCREMENT B+C+D
2036  7510          SPA
2037  5600          RETURN          /C OVERFLO
2040   276          AND     L1777
2041  3277          DCA     TEMP
2042  1060          TAD     D
2043  7510          SPA
```

```
2044  5600             RETURN            /D OVERFLO
2045  1277             TAD       TEMP
2046  3277             DCA       TEMP    /SAVE (C+D) TRIMMED
2047  1252             TAD       B
2050   276             AND       L1777
2051  1277             TAD       TEMP
2052  7110             CLL RAR
2053  3277             DCA       TEMP
2054  1277             TAD       TEMP
2055   275             AND       L6000
2056  7640            SZA   CLA
2057  5600             RETURN            /B+C+D OVERFLOW
2060  1277             TAD       TEMP
2061  1022             TAD       LSPEC
2062  4264             JMS       ADD1
2063  5600             RETURN
                /
2064     0      ADD1,  0000
2065  3300             DCA       TEMP2   /PUT AWAY THE CHANNEL NO. (WD.)
2066  4301             JMS       INCR    /ADD 1 TO WD.
2067     2             0002              /  0002 TELLS INCREMENT ROUTINE TO ADD 1.
2070  2300             ISZ       TEMP2   /WD=WD+1
2071  4301             JMS       INCR    /SUBTRACT 1 FROM WD+1
2072  7776             7776              /  7776 TELLS INCREMENT ROUTINE TO SUBTRACT 1
2073  5664             JMP   I   ADD1
                /
2074  1000      SIEVE, 1000
2075  6000      L6000, 6000
2076  1777      L1777, 1777
2077     0      TEMP,  0000
2100     0      TEMP2,  0
                /
                /CHANNEL INCREMENTING ROUTINE
                /
                /  LOC. (TEMP2) SHOULD CONTAIN ADDR. OF CHANNEL TO BE INCREMENTED.
                /
                /  CALLING SEQUENCES
                /
                /           FOR ADDING 1 TO CHANNEL ..... JMS      INCR
                /                                         0002
                /
                /                                         (RETURN)
                /
                /           FOR SUBTRACTING 1 ..... JMS      INCR
                /                                   7776
                /                                   (RETURN)
                /
2101     0      INCR,  0000
2102  7200             CLA
2103  1701             TAD   I   INCR
2104  3307             DCA       LINCR   /0002 (7776) FOR ADDING (SUBTRACTING) 1.
2105  2301             ISZ       INCR    /SET UP RETURN ADDRESS
2106  1700             TAD   I   TEMP2
2107  7110             CLL RAR           /OVERFLOW BIT INTO LINK
2110  7430             SZL               /SKIP IF NOT ALREADY AN OVERFLOW CHANNEL
2111  5344             JMP       PREVOV
2112  7004             RAL
2113  1307             TAD       LINCR   /A POS. OVERFLOW ( 3776 P 0002 = 4000 ) WILL
                                         /  LEAVE THE LINK = 0, BUT A NEG. OVERFLOW
                                         /  ( 4002 P 7776 = 4000 ) WILL SET LINK = 1.
```

```
2114  3720          DCA  I  TEMP2
2115  1720          TAD  I  TEMP2
2116   370          AND     L3777
2117  7440          SZA                 /SKIP IF CHAN=4000 (FOR OVERFLOW OR UNDERFLOW)
                                        /  OR IF CHAN=0000
2120  5701          JMP  I  INCR
2121  1720          TAD  I  TEMP2
2122   374          AND     L4000
2123  7450          SNA                 /SKIP IF CHAN WAS 4000
2124  5701          JMP  I  INCR        /    RETURN IF CHAN WAS 0000
2125  3435          DCA  I  NEXTLO
2126  7430          SZL                 /SKIP IF OVERFLOW WAS A POS. OVERFLOW
2127  7040          CMA                 /      IF OVERFLOW WAS NEGATIVE
2130  3434          DCA  I  NEXTHI      /FOR POS.(NEG.) OVERFLOW STORE 0000 (7777) IN
                                        /   HI-ORDER WORD OF NEXT OVERFLOW CHANNEL
2131  1035          TAD     NEXTLO
2132  7104          CLL RAL             /SET ADDR. OF NEW OVERFLOW CHANNEL (LO-ORDER)
2133  7001          IAC                 /  AND OVERFLOW MARKER IN OLD CHANNEL
2134  3720          DCA  I  TEMP2       /  LOCATION.
2135  1034          TAD     NEXTHI      /ADVANCE THE OVERFLOW CHANNEL MARKERS
2136  1371          TAD     L0002
2137  3034          DCA     NEXTHI
2140  1035          TAD     NEXTLO
2141  1371          TAD     L0002
2142  3035          DCA     NEXTLO
2143  5701          JMP  I  INCR
              /
2144  3372  PREVOV, DCA     ADDRLO      /ADDR. OF LO-ORDER WORD OF OVERFLOW CHANNEL
2145  7040          CMA
2146  1372          TAD     ADDRLO
2147  3373          DCA     ADDRHI      /  ADDR. OF HI-ORDER WORD
2150  1367          TAD     LINCR       /PICK UP INCREMENT (0002 OR 7776)
2151  7500          SMA                 /SKIP IF IT IS NEG
2152  5357          JMP     INCRLO
2153  7240          CLA CMA
2154  1773          TAD  I  ADDRHI
2155  3773          DCA  I  ADDRHI
2156  1367          TAD     LINCR
2157  7100  INCRLO, CLL
2160  1772          TAD  I  ADDRLO
2161  3772          DCA  I  ADDRLO
2162  7420          SNL                 /SKIP IF THERE WAS A CARRY TO HI-ORDER WORD.
2163  5701          JMP  I  INCR
2164  2773          ISZ  I  ADDRHI      /  INCREMENT HIGH ORDER WORD
2165  7000          OPR
2166  5701          JMP  I  INCR
              /
2167     0  LINCR,  0000
2170  3777  L3777,  3777
2171     2  L0002,  0002
2172     0  ADDRLO, 0000
2173     0  ADDRHI, 0000
2174  4000  L4000,  4000

SYMBOL TABLE

ADD1        2064
ADDRHI      2173
ADDRLO      2172
B             52
BTR           54
```

```
C              55
CTR            57
D              60
DSPEC          21
DTR            62
ESPEC          22
F2ONE        2035
F2ZERØ       2013
INCR         2101
INCRLØ       2157
L0002        2171
L1777        2076
L3777        2170
L4000        2174
L6000        2075
LINCR        2167
NEXTHI         34
NEXTLØ         35
PREVØV       2144
RETURN       5600
SIEVE        2074
SPEC         2000
T              47
TEMP         2077
TEMP2        2100
TTR            51

DUPLICATE TAGS

NØNE

UNDEFINED SYMBOLS

NØNE
```

```
                    /  INTEGRATING PLØT ROUTINE
                    /        ASSUMES DERIVATIVE ØF SPECTRUM IS STØRED AND ØRIGIN
                    /        ØF SPECTRUM + 1 IS PASSED ALØNG AS AN ARGUMENT IN THE
                    /        ACCUMULATØR.
                    /        IT PLØTS FRØM LEFT TØ RIGHT INTEGRATING AS IT GØES
                    /
                    SCALEØ=43
                    *2200
2200       0        INTPLT, 0000
2201    1263                TAD       CØUNT     /PICK UP CØUNT AND ADD TØ ARGUMENT TØ
2202    3264                DCA       ADDR      /  GET ADDR. ØF WØRD TØ BE INTEGRATED
2203    1664                TAD   I   ADDR      /PERFØRM INTEGRATIØN IN 2BLE PRECISIØN
2204    7110                CLL RAR             /ØVERFLØW BIT TØ LINK
2205    7430                SZL                 /SKIP IF NØT AN ØVERFLØW CHANNEL
2206    5252                JMP       OVRFLO
2207    7004                RAL
2210    7500                SMA
2211    5216                JMP       OK
2212    7240                CLA CMA
2213    1270                TAD       SUMH
2214    3270                DCA       SUMH
2215    1664                TAD   I   ADDR
2216    7100        ØK,     CLL
2217    1267                TAD       SUML
2220    3267                DCA       SUML
2221    1267                TAD       SUML
2222    7421                MQL
2223    1270                TAD       SUMH
2224    7430                SZL
2225    7001                IAC
2226    3270                DCA       SUMH
2227    7501                MQA
2230    1272                TAD       P2
2231    7650                SNA CLA             /SKIP UNLESS SUML WAS 7777 (I.E. -1)
2232    5236                JMP       LØADY
2233    1270                TAD       SUMH
2234    7413                SHL
2235      16                0016                /THIS SCALING CØNSTANT CAN BE ALTERED BY CØMAND
2236    6063        LØADY,  DYL                 /LØAD Y
2237    7200                CLA
2240    1263                TAD       CØUNT
2241    6057                DXS                 /LØAD X AND PLØT
2242    7001                IAC
2243     266                AND       L1777
2244    7440                SZA
2245    5250                JMP       .+3
2246    3267                DCA       SUML
2247    3270                DCA       SUMH
2250    3263                DCA       CØUNT
2251    5600                JMP   I   INTPLT
                    /
2252    3264        OVRFLØ, DCA       ADDR      /ADDR. OF LØ-ØRDER WØRD ØF ØVERFLØW CHANNEL
2253    7040                CMA
2254    1264                TAD       ADDR
2255    3271                DCA       ADDRHI    /HI-ØRDER WØRD
2256    1671                TAD   I   ADDRHI
2257    1270                TAD       SUMH      /ADD HI-ORDER PART ØF ØVERFLØW CHAN. TØ SUMH
2260    3270                DCA       SUMH
2261    1664                TAD   I   ADDR
```

```
2262  5216            JMP      ØK
                   /
2263     0  CØUNT,       0
2264     0  ADDR,        0
2265  7777  MI,       7777
2266  1777  LI777,    1777
2267     0  SUML,        0
2270     0  SUMH,        0
2271     0  ADDRHI,   3000
2272     2  P2,       2

SYMBØL TABLE

ADDR       2264
ADDRHI     2271
CØUNT      2263
INTPLT     2200
LI777      2266
LØADY      2236
MI         2265
ØK         2216
ØVRFLØ     2252
P2         2272
SCALEØ       43
SUMH       2270
SUML       2267

DUPLICATE TAGS

NØNE

UNDEFINED SYMBØLS

NØNE
```

```
       7 MINUTES, 18 SECONDS.          1495  LINES.
   END JOB AAU.
```

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